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Annual Report

on the Activities of the Croatian Academy of Engineering in 2006

21st Assembly of the Croatian Academy of Engineering (HATZ) was held in the auditory of the Faculty of Food Technology and Biotehnology University of Zagreb on February 28th, 2006. On the same day before the Assembly a Colloquium "Knowledge-Based Croatia – A Possible Contribution of Croatian Scientists" was held there. Some papers from the mentioned Colloquium are presented in this Annual, while all of them are available on the web pages of HATZ. This Colloquium, as well as a number of other activities throughout the year 2006, have well contributed to the discussions and clarifications of the projects proposed to the Ministry of Science, Education and Sports of the Republic of Croatia (MSES) for the following scientific and research period in the Republic of Croatia, especially in the field of technical and biotechnical sciences through direct discussions between scientists and businessmen. Consultant editors from Croatia and abroad have helped the MSES judgement goups in charge of the selection to propose only the best projects. By the decision of MSES the members of HATZ have become holders of 126 new projects for the coming period of three or five years thus pointing out to the quality and strength of HATZ to contribute henceforth to the development of Croatia based on knowldege.

On the 21st Assembly Assist. Prof. Goran Granić, Ph.D. has been elected new Secretary-General and Prof. Vladimir Medved, Ph.D. has been appointed Administrative Secretary-General with the aim of adequatly following increased activities of HATZ by expert support in administrative services. Detailed survey of the activities of HATZ in 2006 have been published in the Courier of HATZ "Technical Sciences" No. 13 (1) 2006 ISSN 1330-7207, as well as in the Bulletin of the Croatian Academy of Engineering "Engineering Power" No. 5 (1) 2006 ISSN 1331-7210.

On May 9th, 2006 HATZ was informed that “Annual 2004 of the Croatian Academy of Engineering” was included into Thomson Scientific Publications Database, namely into the Index to Scientific & Technological Proceedings (ISTP/ISI Proceedings), as well as in the Index to Scientific & Technological Proceedings on CDROM (ISTP CDROM version/ISI Proceedings). We are expecting for our other Annuals to be included into above mentioned publication databases. In the previous year a statistical survey of HATZ web site visits was made and 129,584 visits were recorded throughout 2006.

As to the international co-operation a special emphasis should be put to the activities intiated in 2005 on the 15th Annual Meeting of CAETS in Cairns, Australia regarding a long-term approach to the education of engineers throughout the world, as well as changes to be expected for the engineering profession due to rapid development of technology and its implementation in the everyday life. Therefore, representatives of HATZ also participated in the 7th World Congress of the World Federation of Engineering Organizations on the education of engineers held in Budapest, Hungary in March 2006. On the occasion the signing of a bilateral agreement on co-operation between the two academies was arranged with the president of the Hunagarian Academy of Engineering, Prof. Janos Gintzler, Ph.D. The signing took place in the House of HATZ in Zagreb on June 28th, 2006 in the presence of Hungarian Embassy representatives in Croatia. Application of the agreement has already been announced for 2007.

Due to the fact that by its memberships in CAETS and in Euro-CASE HATZ has acquired both certain rights and obligations, instead of listing all the activities in which HATZ has taken part through its representatives, it is enough to enter, by way of the web pages of HATZ, into databases of these two global associations and get acquainted with all the oportunities and activities in process. How much use we as individuals or as the society as a whole will have depends on each and every one of us, while the contribution of the delegation of HATZ to these associations has already been emphasised several times in their reports.

In 2005 a programme for a life-long education was accepted and consequently in 2006 in co-operation with the Center of Sustainable Development HATZ began a successful activity having organized the Symposium “Waste Treatment Technologies” in Varaždin from June 12-14, 2006. The success of this Symposium held with the support of the Ministry of Environmental Protection, Physical Planning and Construction of the Republic of Croatia, MSES and numerous firms speaks for itself about the necessity to organize such reunions. A new symposium already announced for 2007 could, according to its programme and interest, by far surpass this one. Those are the exact areas where HATZ has to promote and spread its activities in the future.

In 2006 HATZ continued with the activities accepted by the Croatian Parliament in 2005 and took part in the celebration of "The 150th Anniversary of the Birth of Nikola Tesla". From the very beginning HATZ participated in the activities of the Organizing Committee under the chairmanship of the President of the Croatian Parliament, Mr. Vladimir Šeks and its Operations Board presided by the State Secretary for High Education, Prof. Slobodan Uzelac, Ph.D. Throughout the Nikola Tesla's Year four major international manifestations took place about which it could be stated that they considerably contributed to the performance of the whole programme dedicated to Nikola Tesla in Croatia, while these events also significantly contributed to the reputation of HATZ due to the vast number, quality and expertise of its members who met the expectations of the Government of the Republic of Croatia. Apart from that, the auspices of CAETS and Euro-CASE over the central symposium dedicated to Nikola Tesla and opened in Zagreb on June 27th, 2006 has been awarded to one of its members for the first time.

Chronology:

1. Scientific and professional meeting "The Life and Work of Nikola Tesla" was held on the premises of Vatroslav Lisinski Concert Hall, Techical Museum of Zagreb and the Ministry of Economy, Labour and Entrepreneurship of the Republic of Croatia from June 27 – 29, 2006 in the presence of highest government officials, numerous ambassadors, scientists from Croatia and abroad, leading managers and esteemed guests. Selected papers from this meeting are integral part of the Annual. IEEE as the highest world association in the field of electrical engineering and electronics has been awarded the technical patronage of the meeting.

2. "Tesla in Croatia", the symposium organized by HATZ, MSES and the Ministry of Culture of the Republic of Croatia in the seat of the UNESCO in Paris, France was held on September 13th, 2006 in the presence of the special envoy of the President of the Republic of Croatia, Prof. Izet Aganović, Ph.D., envoy of the President of the Croatian Parliament, Prof. Petar Selem, Ph.D., envoy of the Prime Minis-

ter, Prof. Slobodan Uzelac, Ph.D., as well as the Ambassador of the Republic of Croatia, Mr. Božidar Gagro and numerous employees of missions acredited to the UNESCO. On the occasion, after the patrons' welcoming speeches, our scientists Prof. Stanko Tonković, Ph.D., Prof. Branka Zovko-Cihlar, Ph.D., Gordana Kovačević, M.S., Prof. Stjepan Car, Ph.D., Prof. Kurt Richter, Ph.D., Ivica Toljan, M.S., as well as our publicist Igor Mandić rendered accounts of the life and work of Nikola Tesla in the homeland, abroad, and all circumstances contributing to the assesment of international scientific community that Nikola Tesla became eternal, such as Newton, Amper, Ohm, Volta and some others after which measuring units were universally named. After those scientific lectures a short film made by Croatian Electric Company HEP on the application of Tesla's discoveries in the production and transfer of electrical energy in Croatia was shown. The previous day in the seat of the UNESCO an exhibition dedicated to Nikola Tesla was opened in the organization of the Ministry of Culture of the Republic of Croatia and the Commission of the Republic of Croatia to the UNESCO which was opened up to September 20th, 2006.

3. Marie Curie Workshop 2006 – “Commemorating the 150th Anniversary of the Birth of Nikola Tesla” has been organized in collaboration with the EU, the Ministry of Science, Education and Sports of the Republic of Croatia and the Ministry of Science and Environmental Protection of the Republic of Serbia for young scientists from different EU countries, Croatia and Serbia who, through scientific discussions, have become acquainted with possibilities of co-operation, “Marie Curie” programme activities, as well as with preparations for common projects. The workshop has taken place in Zagreb at the Faculty of Electrical Engineering and Computing of the University of Zagreb and at the Rectorate of the University in Belgrade. The participants were addressed by the Minister of Science, Education and Sports of the Republic of Croatia, Prof. Dragan Primorac, Ph.D. in Zagreb, by the Minister of Science and Environmental Protection of the Republic of Serbia, Prof. Aleksandar Popović, Ph.D. in Belgrade, as well as by the EU Commissioner for Research, Prof. Janez Potočnik, Ph.D. both in Zagreb and in Belgrade. Rector of the University of Zagreb, Prof. Aleksa Bjeliš, Ph.D., Dean of the Faculty of Electrical Engineering and Computing, Prof. Vedran Mornar, Ph.D., as well as Assistant Minister of the Ministry of Science and Environmental Protection of the Republic of Serbia, Prof. Ivan Videnović, Ph.D. in Zagreb, while Provost of the University of Belgrade, Prof. Ljubiša Topisirović, Ph.D. and State Secretary of MSES, Prof. Dražen Vikić Topić, Ph.D. in Bel-

grade pointed out in their speeches to the significance of this workshop held in both states for the first time. In opening speeches by certain subjects several scientists from Croatia and abroad have participated, whereas in the afternoon programme five interesting and successful workshops have taken place, i.e.: "Communicating Science" by Prof. Jasminka Lažnjak, Ph.D., "How to Write a Successful Research Funding Proposal" by Uwe David, Germany, "Alternative Careers and Managing IPR" by Ljiljana Kuterovac, M.S., "Academic Writing" by Vlatko Silobrčić, Academician and "Entreprenurship" by Prof. Vedran Bilas, Ph.D.

4. On November 24th, 2006 a gathering "With Tesla to the Progress of Croatia" took place in the Mimara Museum with the aim that, by the end of the year in which many well-known and unknown facts were presented not only to the scientific community, but also to the public as a whole, no final documents should not be presented, but only programmes based on Tesla's ideas which should instigate technological progress of Croatia in the future. State Secretary for Science of MSES, Prof. Dražen Vikić Topić, Ph.D. held a speech on "Croatian Scientific and Technological Policy", Dean of the Faculty of Electrical Engineering and Computing of the University of Zagreb, Prof. Vedran Mornar, Ph.D. spoke about "The Process of Bologna and Education for the 21st Century", Member of the Board of HEP – Croatian Electric Company, Ivica Toljan, M.S. presented "The Role of Croatia in the Transfer of Electrical Energy in Europe", President of the company Ericsson Nikola Tesla, Gordana Kovačević, M.S. spoke about "Tesla's Vision and Ericsson Nikola Tesla", whereas President of the Board of Končar – Elektroindustrija, Darinko Bago, M.S. presented "New Products Based on the Inventions of Nikola Tesla" and acquainted the attendants with the company's latest achievement, i.e. a regional lowfloor train. From that day on, with the consent of Končar, the regional lowfloor train has been available on the web pages of HATZ.

The budget of HATZ for 2006 was 1,100,000.- kunas. Based on the Interim Statement by the end of 2006 the plan was carried out 136% with the note that all activities were successfully completed and no liabilities transferred to 2007. As to the plan for 2005 the increase was 114% and as to the 2004 it was 250% having been the best indicator of the enhanced efficiency of HATZ in those periods. Beside to the MSES we are particularly grateful to the industry (Končar Inc., Nikola Tesla Ericsson Inc. and HEP Inc.) for the support during celebration of the Nikola Tesla year.

By such activities and endeavours of the majority of the members of HATZ, we are able to meet the expectations of our governmental institutions, academic community, firms and all citizens of the Republic of Croatia, but also of the international community about which testify numerous acnowledgements, medals, appointments and rewards received by our members throughout 2006. Many thanks to all of them.

Prof. **Zlatko Kniewald**, Ph.D.
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The Ocean and its Environment as a Source of Food Production[1]

Introduction

Oceans contain 97% of the earth's water while the other 3% is determined as freshwater. More than 70% of freshwater resources are stored in the ice and only 1% is a surface freshwater important for the human, animal and plants life, but also for the each day higher industry demands. On the other side, marine organisms are found in communities, groups of interacting producers, consumers and decomposers that share a common living space. Each species within the community has a particular habitat: a specific location that it occupies within the community and a specific role that it plays within the community. Every species requires a balance of particular physical and biological factors to exist and thrive. While organisms within a community compete with each other for space, food and other resources, they also depend upon one another in specific ways. The ecosystem, energy flow and nutrient cycling are prerequisites that provide sustainable environment within oceans, including solar energy, primary production (e.g. phytoplankton), herbivores (e.g. zooplankton), carnivores (e.g. fishes) and decomposers (different microbes e.g. bacteria). While the ecosystem is a closed circle, we have two types of water pollutants called point source and nonpoint source and both are extremely harmful to the ocean environment and water as a whole.

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[1] Lecture presented at *Oceans and the World's Future: 16th Convocation of the CAETS* Cairns, July 10–14, 2005, Queensland, Australia.

Key words

Ocean environment, food sources, aquaculture pollutian

Biological productivity in the ocean

An ecosystem is the totality of the environment encompassing all chemical, physical, geological and biological parts. Ecosystem is functioning by the exchange of matter and energy. Plants are autotrophs and the primary producers in most ecosystems. They use chlorophyll in photosynthesis to convert inorganic material into organic compounds and to store energy for growth and reproduction. All other organisms are heterotrophs, the consumers and decomposers in ecosystem. Herbivores eat plants and release stored energy. Material is constantly recycled in the ecosystem, but energy gradually dissipates as heat and is lost. Word "trophic" refers to the nutrition, and trophic dynamics means the nutritional interconnections among organisms within an ecosystem. So, trophic level is the position of an organism within the trophic dynamics: the first trophic level forms autotrophs, the second – herbivores, while the third and higher trophic levels are occupied by carnivores and decomposers from the terminal level. The food chain is the succession of organisms within an ecosystem based upon trophic dynamics: who is eaten by whom. An energy pyramid represents a food chain in terms of energy contained at each trophic level.

As the primary producers, plants require sunlight, nutrients, water and carbon dioxide for photosynthesis, while animals must consume pre-existing organic material, which breaks down into their inorganic components to obtain the stored energy. Food chains transfer energy from one trophic level to another. Biomass is the quantity of living matter per volume of water, and with each higher trophic level, the size of organisms generally increases, but their reproductive rate, number and the total biomass decrease. The two major food chains in the ocean are the grazing food chain and the detritus food chain – non-living wastes from the base of the food chain.

Primary production is the total amount of carbon in grams converted into organic material per square meter of sea surface per year (gm $C/m^2/yr$). The factors that limit plant growth and reduce primary production include: solar radiation and nutrients as major factors and upwelling, turbulence, grazing intensity and turbidity as secondary factors. Productivity varies greatly in different parts of the ocean in response to the availability of nutrients and sunlight. Primary productivity varies from 25 to 1250 gm/C/m^2/yr in the marine environment and is highest in estuaries and lowest in the open ocean. In the open ocean productivity distribution resembles a "bull's eye" pattern with lowest productivity in the center and highest at the edge of the basin. Continental shelves display moderate productivity between 50 and 200 gm/C/m^2/yr, because nutrients wash in from the land and tide- and wave-generated turbulence recycles nutrients from the bottom water.

It is possible to estimate plant and fish productivity in the ocean. The size of the plankton biomass is a good indicator of the biomass of the remainder of the food web. Transfer efficiency is a measure of the amount of carbon that is passed between trophic levels and is used for growth, and varies from 10 to 20% in most food chains. The rate of productivity is very low for the open ocean compared to areas of upwelling; the open ocean has the greatest biomass productivity because of its enormous size. In the open ocean the food chains are longer and energy transfer is low, so fish populations are small. Most fish production is equally divided between area of upwelling and coastal waters. The calculations suggest that the annual fish production is about 240 million tons/yr. Over-fishing is removing fish from the ocean faster than their ability of being replaced by reproduction and it can eventually lead to the collapse of the fish population.

Upwelling of deep, nutrient-rich water supports large populations of phytoplankton and fish. Upwelling are the currents that move from the euphotic zone to the photic zone and thus bring nutrients into the photic zone and in this way are responsible for new production. About 25% of global marine fishes come from five upwelling areas making up 5% of ocean surface area. Wind-induced coastal upwelling encompasses the sites of high production. Major coastal currents associated with upwelling are: California, Peru, Canary, Benguela, and Somali currents. The waters of the coast of Peru normally are an area of upwelling, supporting one of the world's largest fisheries. Every three to seven years warm surface waters in the Pacific displace the cold, nutrient-rich water on Peru's shelf in a phenomenon called El Nino. El Nino results in a major change in fauna on the shelf and a great reduction in fishes. This can lead to mass starvation of organisms dependent upon fish as their major food source.

Upwelling regions account for 1% of the ocean, but produce more than 80% of global fisheries because of higher primary production (PP) and lower energy losses through the food chain (Table 1).

Table 1. Primary *vs.* fish production

Ecosystem	Oceanic	Coastal	Upwelling
% area	89	10	1
PP (gm C/m^2/yr)	75	300	500
Global PP (gm C/yr)	24	11	1.8
Trophic levels	5	3	1-2
Energy transfer efficiency	10%	15%	20%
Fish production (gm C/m^2/yr)	0.75	1000	44700
Global fish production (gm C/yr)	0.24	36.2	162

Organic matter in the ocean is living material (bacteria, phyto/zooplankton, larger fish etc.) and non-living material (organic detritus: dead remains of all organisms, fresh and non-fresh, large or small). Two main categories of organic matter exist in the ocean: dissolved organic matter (very small >0.45 μm) and particulate organic matter (anything larger than that, e.g. marine snow and facial pellets). Dissolved organic matter is >95% of total organic matter in the oceans (685 billion tons of carbon) and is produced by all organisms as metabolic by-products (excretion and exudation). Microbes can also contribute to dissolving of the organic matter. How much of it participates in biological processes? Microbes have many roles in the marine ecosystems: they decompose organic matter and release nutrients back into the environment; they are a food source for many small zooplankton and some are primary producers (autotrophs). The main role of marine microbes in eutrophic waters is to recycle organic matter back to mineral constituents. In oligotrophic waters the role of the microbes is split between recycling and serving as a direct food source to certain zooplankton. Decomposition of dissolved organic matter continues throughout the water column. However, the nutrients are used up in the surface for photosynthesis and this leaves the deep waters rich in nutrients.

Ocean as a food source

There is still a trend for greater use of marine biological resources for food. Usually the eutrophic zone in which photosynthesis can occur is approximately only 60 m deep and it is where we find the highest concentration of primary producers. The coastal zone has a high productivity because of its proximity to the sources of mineral nutrition. Large-scale direct cropping of phytoplankton does not yet seem to be a very feasible food or fodder source. The removal of organisms would mean taking away nutrients and these would have to be replaced. Zooplankton presents similar cropping problems. The third trophic level yields a great number of desired species. At each stage there is competition for the production by species, which are not important resources of food for man. A further harvest comes from detritus feeders, which scavenge from the sea floor.

World fish landings ran at 70 million megatons and approximately half of the crop is consumed directly by humans, while the rest is being used as livestock feed. The consumption of fish *per capita* is highest in developed countries, Japan, Australia, United States and European countries and their livestock are also being major users of fishmeal.

The potential for extended fisheries comes from three sources: the utilization of untapped species, the cropping of hitherto unattractive areas and the development of more novel methods of culture and harvesting. In the future, less direct ways of increasing the crop of marine resources could be systematically investigated. When nutrients are limited, fertilization by the addition of minerals to the sea allows higher productivities.

True aquaculture involves genetic manipulation of the chosen species by keeping them captive throughout their breeding cycle, a difficult though not impossible risk. The requirements are unpolluted seawater and a suitable coastal site with adjoining land. A general disadvantage of aquaculture seems to be the considerable skill needed for success. The sources for fine chemicals and pharmaceuticals (e.g. β-carotene from algae *Dunalliela salina*) should be used as food or feed additives.

The food resources of the sea can, under the most optimal circumstances, never be a panacea for all nutritional problems of the world. Only one quarter of the present world population could be fed of marine food, because the main use of marine food is for protein.

Fish capture, seafood harvesting and aquaculture

The global fish capture efforts have steadily grown over the past several decades in response to growing demand for fish both as a staple and, in some instances, as a high-value food source. There is increasing concern, however, that fish stocks may not be able to sustain this accelerated growth or even allow us to maintain current fishing levels (Figure 1).

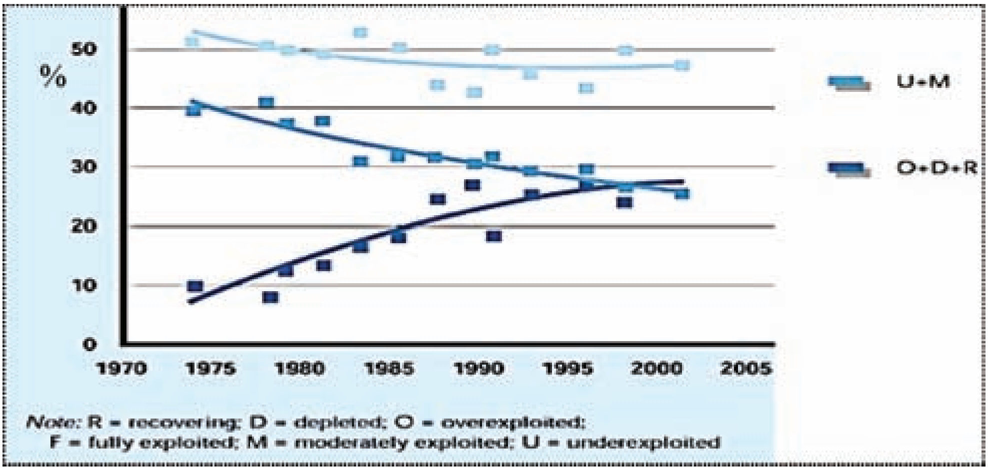

Figure 1. Global trends in the state of world fish stocks since 1974 (FAO, 2002)

While the world demand for fish is expected to increase for the foreseeable future due primarily to population growth and the increasing income per capita, the potential for capture fisheries growth is finite. Approximately 75% of the world's fishing area are at their maximum potential for capture fisheries production or are to some degree overexploited or even depleted. Speaking in global terms, there is an excess of fishing capacity and some technologies, which enable fishers to indiscriminately capture more fish, only exacerbate the situation. Most of the opportunities for growth are in the underexploited or moderately exploited areas of the East Indian and West Central Pacific Oceans (Technology Roadmap, 2005).

The FAO predicts that total demand for fish will grow by 9 to 20% from its 1999 level of about 125 million tons driven mostly by increasing demand for food fish. Aquaculture production over the 1994-1999 period grew by about 58%, however, and continued high growth rates are anticipated, although perhaps not at this level. The ability of capture fisheries to contribute to anticipated growth in demand will, therefore, depend on further development of underexploited and moderately exploited areas and also on the effectiveness of fisheries management. Improved management of currently over-fished stocks could provide an increase of between 5 and 10 million tons, whereas continued practices will likely lead to declining production. Most of the required increase in fish production is expected to come from aquaculture.

Aquaculture, or the farming of aquatic species for food and other uses, has become increasingly important in many areas of the world. It is one of the fastest-growing segments of the entire marine sector. The great attraction of the aquaculture industry is that it can provide a high-quality protein at much less cost, energy input and generally less negative environmental impacts than other sources of protein such as beef and pork. Another reason for the growth of aquaculture is the increasing use of multiple aquatic species – both animals and plants – as a source of new pharmaceuticals, nutriceuticals, and other important biological materials. This aspect of aquaculture is much less developed as science has only begun to explore the different marine materials available, their nature and potential uses. Much of the technology development focus in this area has been on extraction of useful materials from wild stock or by-product as opposed to actually growing dedicated stocks for such purposes. However, this is expected to change as more, and increasingly valuable applications are discovered, especially those involving rare or difficultly obtainable species. This changeover will occur when it becomes more economic to grow the source stock rather than harvest it from the wild. Aquaculture is also attractive because it is suited to, or adaptable to, a wide range of species in many different environments. Therefore, it is an area with very great growth potential from a market perspective.

Aquaculture activity is primarily focused at present on Pacific and Atlantic coasts with some modest freshwater aquaculture. Generally, aquaculture activities are primarily distinguished on the basis of three categories:

- Fin fish e.g. salmon, trout, cod;
- Shellfish e.g. scallops, mussels, clams, oysters: and
- Seaweed.

While the emphasis on shellfish harvesting is anticipated to continue into the foreseeable future, there is also some doubt about the long-term biological limits to such fisheries and their sustainability. There is some concern, for example, that the demise of cod and other ground-fish stocks as well as the increase in some shellfish species are associated with lower water temperatures, which may revert over time. There are strong drivers for innovation and adjustments that transfer the risks involved in the capture fishery and bring greater stability and growth to the fishing industry. The key players from the industry are already addressing this form as a structural and innovation standpoint by trying to bring industry fishing capacity in balance with current resource carrying capacity. There is a need to better understand the underlying science behind variations in stock abundance from which better fisheries management and innovation practices can be developed, resulting in more abundant and sustainable fisheries. While significant progress has been made, more research needs to be done utilizing new approaches and applying new technologies.

World Fisheries

For much of world's population, fish is a major source of protein. Therefore, the health of the world's fisheries is a critical concern for many island nations and coastal communities that rely on fishing either as a commercial activity or as a means of subsistence.

Seafood is the primary source of animal protein for as much as one-sixth of the world's population. The primary issue in fisheries conservation is over-fishing. According to the FAO, the majority of commercial fish stocks have been exploited at their full potential, and several important fisheries need to be carefully managed to prevent collapse. The Atlantic cod fishery, for example, which for centuries has sustained communities in both the United States and Canada, has collapsed in recent decades, and despite conservation efforts is showing few signs of rebounding (Figure 2).

Worldwide, 80-90% of the global fish catch takes place along the world's coastlines and in upwelling systems where nutrient-rich deep-water currents run up against continental margins (Figure 3). Nutrient-rich conditions that favor fish production along coasts lead also to increased vulnerability to risks posed by human activities. Over-fishing in effect is the story of, for instance, the virtual disappearance of oysters in the Chesapeake Bay. Along with other natural and human-caused factors, over-fishing alters coastal and ocean ecosystems, and contributes to the decline of fish stocks worldwide (Metcalf 2003).

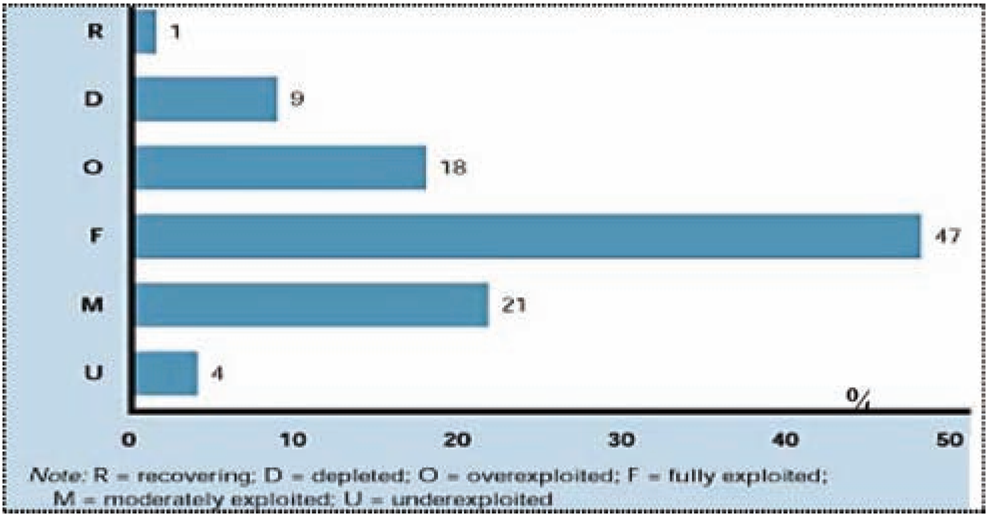

Figure 2. The state of stock fisheries (FAO, 2002)

Maximum sustainable yield is the goal of fisheries management, but there is some agreement that this may be too simplistic an approach, because it is difficult to estimate total populations in fish species. For most fish stocks, the only data that are available is the yield, or the number of fish caught. Another indicator used in fishing intensity is the number of fish caught per unit of effort, such as days or boat hours. When yields decline, that is when fewer fish are caught, or it takes more effort to find and catch fish, there is evidence that the population is over-fished. However, fish populations vary due to factors other than over-fishing, including changes in water temperature and variability in ocean currents, among other things. In addition, overstating or understating yields adds additional uncertainty to management of fisheries. And even more than other environmental and conservation issues, fisheries management is difficult for a single country to control or legislate. The oceans are a global commons, they are owned in common, and it is difficult to establish property rights over the resources they contain. That means that everybody who uses the sources has an incentive to get their share as quickly as possible before the resources are depleted. Therefore, there have been a number of important international treaties that seek to regulate the exploitation of the world's fisheries. Enforcement of these treaties remains a challenge.

The results of over-fishing can be seen not only in the absolute numbers but also in quality and size of certain species of fish available to consum-

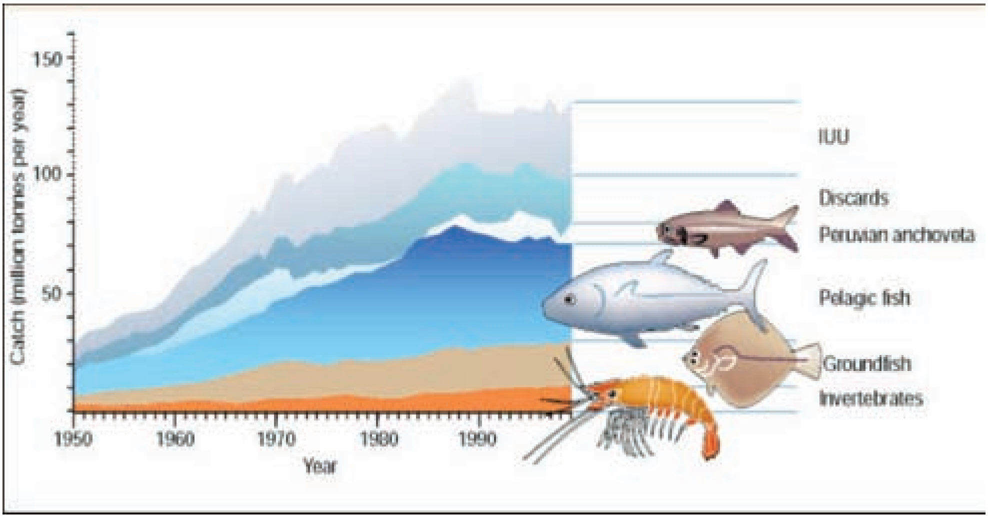

Figure 3. Global catch in the oceans from 1950 to 2002 (Pauly *et al,* 2002)

ers. One phenomenon, known as "fishing down the food web", involves the systematic removal of the largest top-level predators, usually the most valuable fish species in a system (Figure 4). As a result, smaller and less valuable species (typically prey or forage species) are caught increasingly. Marine ecologists point to research showing that the combined effects of over-fishing, by-catch, habitat degradation and fishing-induced food web changes can alter the composition of entire ecological communities.

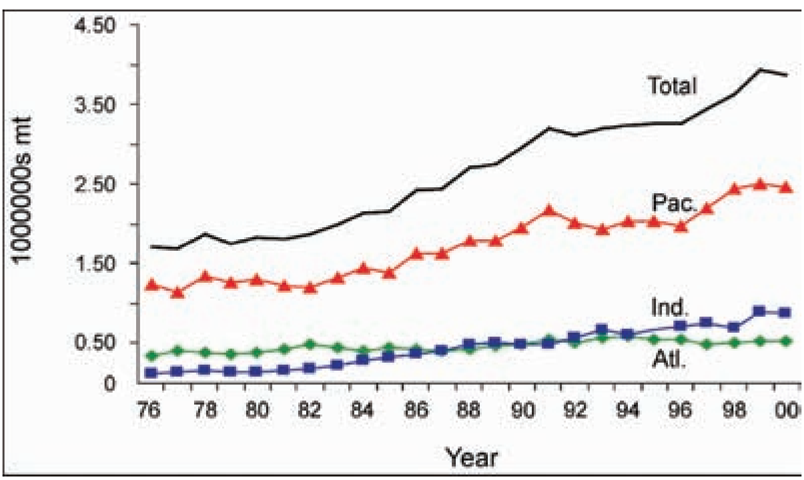

Figure 4. Trends in the catch of the principal market species of tunas by ocean (Squires, 2004).

By-catch is the incidental catching, discarding or damaging of living marine resources when fishing for targeted species. Worldwide annual by-catch is estimated at nearly 60 billion pounds, that is roughly 25% of the overall catch. It is evident, that for instance shrimp trawling leads to discards of five pounds of shrimp for every pound caught. Other fish with high rates of by-catch include Patagonian tooth-fish (Chilean seabass), trawl-caught Atlantic cod, haddock, monkfish, and dredged scallops. By-catch is generally less for hook-caught fish such as rod- and reel-caught yellowfin tuna, pole-caught skipjack tuna and trolled albacore tuna. Declines in one species can alter the relationships of prey to predators and thereby pose risks to entire ecosystems. In an example, over-fishing of reef-dwelling trigger-fish and puffer-fish resulted in an explosion of the sea urchin population, which in turn damaged Caribbean corals by overgrazing protective layers of algae. Fewer numbers of adult species can also mean less genetic diversity among spawning populations and reduced ability to adapt to future environmental changes. Disruption of prey to predator relationships also can increase ecosystem vulnerability to invasive species.

Bottom fishing and other destructive fishing methods can scour vast areas of seabed, crushing and burying bottom dwelling species. Although, marine species were once assumed to be virtually immune for extinction, but this is no longer a case.

In addition to over-fishing, some fishing practices have significant impacts on marine ecosystems. Trawlers that drag nets along the ocean floor damage the habitats that support fisheries and also sweep up non-target species. Global by-catch amounts millions of tons, and includes charismatic animals such as dolphins and turtles, but also many other species. Human activities also affect fisheries indirectly through agricultural runoff and increased erosion, and by altering coastal ecosystems, particularly mangrove forests, where many fish species breed. Aquaculture has grown significantly over the last decade, particularly in Asia and the Pacific. It has been estimated that 60% of Asia's mangroves have been converted to aquaculture farms. Aquaculture reduces the pressures on ocean stocks, but improperly management has led to a number of environmental problems, including the release of pathogens, nutrients, and potentially hazardous chemicals into coastal waters.

Fisheries are a critical source of animal protein for many countries, particularly those in Asia and parts of Africa. But fish is used for more than human consumption. One fourth of the global fish catch is turned into livestock feed, fish oil, and other products. The demand for fish is expected to grow, placing additional pressures on marine ecosystems. There is a number of initiatives, however, to manage fisheries sustainable. For example, the South Pacific tuna fishery offers a successful model of international cooperation for sustainable ocean fisheries.

Wild fish restoration is a global challenge

The world's oceans are close to giving up all they can in marine stocks, according to a report released March 7, 2005 by the FAO of the United Nations (Environmental News, 2005).

The State of World Fisheries and Aquaculture (SOFIA) reports that 24% of the world's fisheries are overexploited, depleted or in recovery from depletion. More than 50% are "fully exploited", or fished to their maximum capacity to replenish. The remaining 21% are "moderately exploited and could support modest increases in fishing and in harvests". Also, seven of the top 10 marine fish species, accounting for about 30% of all capture fisheries production, are fully exploited or overexploited. Rebuilding depleted wild fish stocks is a challenging necessity, as reported by UN FAO, and at the same time demand for fish will continue to rise.

To restore fish populations, there is a need for decreasing or temporarily stopping fishing in overexploited fisheries, reducing degradation of underwater environments, and actively rehabilitating damaged habitats. Yellowfin tuna comes aboard during pole and line fishing operation in the tropical ocean. The Northeast Atlantic, the Mediterranean Sea and the Black Sea, are the regions with fish populations in greatest need of recovery, followed by the Northwest Atlantic, the Southeast Atlantic, the Southeast Pacific and the Southern Ocean. China remains by far the largest producer, with reported fisheries production of 44.3 million metric tons in 2002, 16.6 million tons from capture fisheries and 27.7 tons from aquaculture.

According to FAO, there has been a consistent downward trend since the 1950s in the proportion of marine fish stocks with potential for expanded production, coupled with an increase in the proportion classified as overexploited or depleted. SOFIA offers several ideas for replenishing fish stocks, decreasing or stopping fishing in some waters, reducing degradation of underwater environments and restoring damaged marine habitats. Global fish production has reached a new height and at the same time human consumption of fish is increasing.

Currently, SOFIA reports, 3% of marine stocks are underexploited, while 21% are moderately exploited and could support modest increases in fishing and in harvests. The stocks that are overexploited cannot be expected to sustain major increases in catches, and serious biological and economic drawbacks are likely to occur if fishing capacity for these stocks is further increased. Fifty-two percent of fish stocks are fully exploited, which means they are being fished at their maximum biological productivity. Increased fishing of these stocks would not produce any additional sustainable harvests and would reduce reproduction to dangerously low levels. The remaining 24% of stocks are overexploited (16%), depleted (7%), or recovering (1%) and need rebuilding. Some of these stocks are already under strict management schemes.

Considering the limited progress achieved in the last decade in this respect, restoring depleted stocks to healthy biomass levels by 2015 represents “a high-order” challenge. Despite these challenges, global fish production reached a new height of 133 million metric tons in 2002, as the result of expanded production on fish farms. Overall, the share of world fisheries production attributable to aquaculture increased from 25.8 to 29.9 % between 1998 and 2002. During the same period, production from capture fisheries grew by 6.3% while aquaculture production increased by 30%. Most of the growth in capture fisheries occurred between 1998 and 1999, while since 2000 has remained generally stable. However, the fleet sizes of some major fishing nations are shrinking. That has been most pronounced in 15 EU countries, especially those that combined fishing fleet decreases from 96,000 vessels in 2000 to 88,701 in 2003. The Russian Federation had the highest fleet capacity measured in gross tons in 2003, as 24% of the total tonnage of the world fishing fleet followed by Japan and the United States with 7% each, Spain 6%, Norway 3.5% and Ukraine 3%.

The growth in aquaculture will not make improvements in current fishing practices and management any less important, and in light of current trends, the continued improvement of management of wild fish stocks is essential. Aquaculture may help reduce pressure on capture fisheries by reducing demand for wild fish and lowering prices, but that's only part of the solution.

At the same time as the fish stocks are decreasing, human appetite for fish and fish products is growing. Human consumption of fish increased from 93.6 million metric tons in 1998 to 100.7 in 2002.

In 2005 is the 10th anniversary of the adoption of the FAO Code of Conduct for Responsible Fisheries, a non-binding instrument that provides a blueprint for responsible fishing practices. All 188 FAO Member states have committed to use the Code to strengthen their own fishing policies and improve international cooperation on fishing management. According to the FAO report on March 5, over the last 10 years there were countries and fisheries bodies around the world that have drawn on the Code to improve fisheries management. Much progress has been made, but still more needs to be done during the next 10 years. Ultimately, the only real tangible sign of success will be the clear reversal in the resource trends and related improvements in the situation of fisheries (USINFO.STATE.GOV., 2005)

Human impact on ocean's environment

Coastal waters, including coastal wetlands and reefs, account for only 10 %, whereas the relatively less productive open oceans constitute 90 % of the total area of the global marine environment. The coastal waters and ecosystems are highly productive biologically and very important for human society. Until now, and particularly in the next decades, a significant consequence of many projections has been and will be a dramatic growth in coastal development. Dredging, filling, paving and construction of terminals, factories, settlements and roads will increase water pollution, and will greatly reduce productivity, diversity and stability of coastal and the adjacent ecosystems. Increasing marine traffic transport may bring further pollution.

The introduction of non-native species into coastal ecosystems may influence biological diversity but it does not mean also any particular problem. Estuaries and coastal wetlands accumulate natural, river-borne as well as wastes from nearby industrial and urban areas. It is estimated that 60 to 80 % of the commercial marine fisheries species are dependent upon estuarial ecosystems. Salt marshes and mangrove communities are distributed all over the world and are either associated with estuaries or coastal islands. The marsh environment creates an area of biological productivity that then yields 10 megatons of organic material per acre per year. The tropical mangrove communities are highly productive as well. Salt marshes have been regarded globally as prime areas for industrial setting. Mangrove ecosystems are also facing destruction through development. Coral reefs are among the most extensive and productive shallow marine communities, but also have been modified or damaged entirely as a result of inappropriately planned and managed dredging.

Coastal waters constantly receive polluting materials through river discharge, coastal outfalls, and dumping and atmospheric transport. Point sources of pollution occur when harmful substances are emitted directly into a body of water, while a non-point source delivers pollutants indirectly through environmental changes. An example of this type of water pollution is when fertilizer or pesticide (e.g. atrazine) from a field is carried into a stream by rain, in the form of run-off, which in turns effects aquatic life. Toxic waste pollution is one of the most serious threats to the health of the coastal oceans. Toxic substances include those that are carcinogenic, mutagenic and teratogenic. Only few chemicals are adequately tested for toxicity and environmental hazards. Studies to determine environmental persistence, transport, and long-term biological effects are expensive and synergistic effects complicate analysis of the data. Synthetic organic chemicals (e.g. DDT, PCBs) have been reported as causing a reduction in the photosynthetic rate of marine algae even at very low concentrations, proved to be toxic to fish, and toxic to some marine organisms. Waters from rivers on Tasmania's northeast coast are toxic to sea urchin larvae, a species used in European research as a model for pre-cancerous changes in human cells. Present toxic chemicals include atrazine, a possible human carcinogen and α-cypermethrin, which are toxic to oysters in trace quantities (Miller, 2005). Our published papers as the result of long-term investigation concerning the atrazine toxicity (Kniewald *et al*, 1987; Šimić *et al*, 1994; Kniewald *et al*, 2000; Kniewald, 2003) have described reproductive toxicity with synergistic effects in the presence of other herbicides.

The other toxic substances are heavy metals, and pollution is most evident in the coastal zones, especially where mixing processes are slow. Most heavy metals are bioaccumulated in different components of the marine food web and are deposited relatively rapidly in the sediments of the coastal zones where they may play a determinating role in biological processes. Heavy metals enter estuarine and marine environments *via* a range of point and diffuse sources. Primary sources of emissions are industrial, sewage and storm-water discharges and mining operations near coastal rivers. The metals of most concerns are mercury, copper, cadmium, lead and zinc. Species that occupy the seabed or filter particles from the water column are most impacted and accumulate high concentrations of heavy metals in their tissues. The effects of this are lethal by inducing alternations in species compositions and reduced biodiversity near sources of heavy metal emissions. However, many species experience sub-lethal or non-lethal effects at certain concentrations and are commonly used as bio-indicators for heavy metal pollution. Fish may also accumulate high levels of metals in their tissues, and food safety guidelines are always periodically exceeded for some species. In severe cases of contamination, fish kills have resulted from metals accumulating in gill tissue and interfering with oxygen uptake. Elevated concentrations of metals such as mercury (Table 2) and cadmium can also occur in the flesh of large and wide ranging predatory fishes, seabirds and dolphins due to the effects of bio-accumulation and bio-magnification. There is an evidence of human impact on the food sources from the oceans (Guallar, 2002; Murata, 2004).

Table 2. Concentrations of methylmercury in fish and commonly eaten fish (US EPA, 2004; Knowles *et al*, 2003)

Kind	Concentration in ppm
shark, swordfish, king mackerel, tile fish	0.73 – 1.45
bass, bluefish, grouper, halibut, lobster, marlin, orange rough, canned albacore tuna, fresh tuna	0.25 – 0.55
anchovies, catfish, clams, cod, crab, haddock, perch, pollock, salmon, scallops, shrimp, trout	< 0.1
canned light tuna	0.12
canned albacore tuna	0.35
fresh or frozen tuna	0.38

There are also other chemical emissions including wastes from pulp, paper and woodchip mills, food processing works, salt and chemical plants and oil refineries. In many cases, industrial wastes are discharged to municipal sewage treatment plants, where they are combined and treated with sewage wastes, while chemical toxicants also enter estuarine and marine environments *via* urban and agricultural run-off. The range of industrial chemicals released is extensive, but includes mainly: dioxins, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides, resin acids and organic halogens. The effects of many of these chemicals on marine life yet are not completely understood, however toxic effects on fish and other aquatic biota have been identified. Also bio-accumulation in seabirds and marine mammals has been linked to reduced breeding success (National Ocean Office, 2005). Elevated levels of suspended solids, biological oxygen demand (a measure of organic content), nutrients and, in the case of timber and paper mills, woodchip fiber, also commonly characterize industrial discharges. While these components of emissions are essentially non-toxic, they have significant impacts on estuarine and marine biota through habitat alternation and degradation of water quality.

The impacts of pulp and paper mill contaminants on biota are specific to mill technologies used, treatment processes, effluent types and the nature of the receiving environment. In estuarine environments, impacts on fish have been reflected by avoidance responses to pulp mill effluent, fin damage, and fish kills during mobilization of sludge masses by flood events. The impacts are less severe at open coastal sites, such as reductions in diversity of inter-tidal fauna, as well as growth of nuisance algae and modification of sub-tidal communities. The chemicals such as PAHs and PCBs exhibit high degrees of bio-accumulation in marine food chains with impacts on fish health, for instance: lesions, eye damage and high external parasite loads.

Thermal waters are discharged from a number of power stations, as well as from a wide range of industrial sites. Thermal discharges result in plumes of heated water in near-shore coastal and estuarine environments. Most severe biological impacts are likely to occur within 100 m of the discharge, but changes in community structure may occur over several kilometers. Sessile species, such as sea-grasses and a range of benthic (bottom-dwelling) invertebrate species, are most impacted by thermal plumes. Invertebrate communities exhibit changes typifying environmental stress, with a small number of highly tolerant, opportunistic fauna becoming abundant, replacing more diverse communities. In addition to altering temperature regimes, thermal discharges result in alternations of the sedimentary environment and water clarity and frequently lead to increased growth of microalgae, epiphytic algae and other nuisance flora. Severe die-back of sea-grass beds during unusually warm conditions indicates that tolerances could be exceeded as a result of some thermal effluents. Thermal pollution has a significant impact on the distribution and abundance of native fish species in estuarine and coastal systems. While fishes have the mobility to escape lethal effects of thermal waters, they are affected through behavioral changes. The implications of the behavior may include reduced breeding success through preventing migration to spawning sites. At certain times of the year, some species of fish are attracted to thermal outfalls, at which time they are highly exposed to any toxic contaminants contained in the discharge (National Ocean Office, 2005).

The impacts in receiving estuarine and coastal waters include nutrient enrichment and eutrophication, bacterial contamination, oxygen depletion, elevated turbidity, and acute and chronic toxicity to biota. Nutrients from storm-water have been linked to nuisance growth of green macroalgae such as sea lettuce (*Ulva sp.*). Under certain conditions, these algal growths can accumulate in beach areas, forming large decomposing drifts, and smothering benthic habitats. Storm-water discharges have also been implicated in sea-grass loss and degradation, mangrove and saltmarsh dieback and the increasing frequency of red tides formed by blooms of microalgae. These impacts occur as a result of reduced light attenuation associated with turbid waters and smothering of the seabed and tidal flats with sediments and algal growth.

Land clearance for agriculture and other rural industries, such as forestry, results in significant increases in catchments run-off. This run-off contains a combination of animal wastes, fertilizers, pesticides, agricultural chemicals and soil, and is a major source of elevated sediment and nutrient loadings in estuaries and coastal waters. High levels of dissolved solids and nutrients in agricultural run-off result in degradation of water quality and sedimentary habitats, and have been implicated in loss of seagrass cover.

Sewage effluent is very high in organic matter and nutrients and therefore causes water quality degradation primarily through eutrophication, oxygen depletion and elevated turbidities. A bloom of cyanobacteria and toxic microalgae has also been triggered by the high nutrient loads and subsequently contaminates and, in extreme cases, causes mortality of shellfish. Sewage discharges are also directly linked to widespread seagrass loss and mangrove dieback. The disappearance of the productive seagrass and mangrove communities has significant ramification for commercial and recreational fishes.

Artificial radioactive materials are the other sources of the toxicity for the marine ecosystems. The largest source of radioactive materials entering the oceans has been nuclear explosions. Although the nuclear tests ban has reduced the rate at which radioactive materials enter the seas, the nuclear energy production and the use of radioactive materials has continued the flow of radioactive isotopes into the terrestrial environment and the oceans. Transuranics, fission products, and induced radioactive species are now found in seawater and in ocean biota almost universally. The biological or environmental significance of this contamination is virtually unknown.

The fossil fuels are the next serious contaminants in the marine environment. Sub-lethal and long-term damage to marine ecosystems may result from chronic discharges and accidents during normal offshore and dockside operations, from disposal of drilling mud and cuttings, and from disturbance of the seabed and coastal wetlands by platform and pipeline construction. The influence with which fossil fuel pollutants affect the marine environment varies. It is now well established that petroleum hydrocarbons adversely affect a wide variety of marine organisms.

There are plenty of other problems as sewage, fertilizer nutrients, solid waste and sedimentation on a global scale of the marine environment pollution. Fifty years ago, most pollution was not seen in our oceans, since it was comprised mainly of metal and glass, which sink, and paper and cloth, which decay. Today, pollution is more visible because many of the manufactured objects are made of plastics, which are light-weight, strong, and very durable. Not only do plastics, as they are commonly produced, degrade slowly, but some animals see plastics as food and ingest them, or they become entangled in them. In either case, the result is usually death.

But, there are still some parts on the seawater area where pollution is still not present due to the undeveloped industry or river flows moving toward other great seas. The Adriatic Sea for instance, particularly the eastern side, is among these still not polluted areas as much as others. But we are scared what will happen in the future also in that area.

Quality of ocean's food today and tomorrow

The food coming from the marine communities we can separate as follows:

Rocky Intertidal Community

The intertidal zone is the area between high and low tides. Large quantities of food and sunlight make this a desirable community with high biodiversity. But to reap the benefits, organisms inhabiting this community must be able to withstand: desiccation (drying out), waves shock, drastic changes in temperature and salinity. Rocky intertidal organisms deal with these factors as motile animals crawl under rocks or overhang for shelter or sessile organisms hanging on tightly to rocks, and often having low profiles and tough shells. But these organisms are greatly influenced by different toxicants present in their neighborhood.

Sand Beach and Cobble Beach Community

Beaches are demanding environment for organisms. Only few species can tolerate problems with wave shock and desiccation or loose sand. These communities have very low biodiversity, and only few species that can thrive here often become very abundant, feeding on abundant plankton and food particles washed in by waves. Such organisms are interstitial animals – tiny creatures that live in the spaces between sand grains. Salt marshes and estuaries are rich in nutrients and have abundant sunlight, what results in very high primary production, yielding an abundant food supply to support many organisms. Due to the brackish water – a mixture of freshwater and seawater, ranging temperature and salinity, these communities are very resistant. But such environment is of great importance for many juvenile organisms, especially for fishes. Many fishes are born and grow up in estuaries, and later migrate to the open ocean. Because these communities usually occur at the mouths of rivers, they are very vulnerable to xenobiotics that are washed down the rivers from urban, agricultural or industrial (pharmaceutical or petrochemical) areas.

Coral Reef Community

Coral animals (*Phylum Cnidarians*) create coral reefs. They secrete skeletal structures of calcium carbonate rising up from the sea floor, creating habitat for vast number of species. Coral reefs have the greatest biodiversity of any marine community. More than one million species inhabit the coral reef ecosystem.

Open Ocean Community

Communities in the open ocean depend on food produced by organisms in surface waters above. At the same time deep sea floor, due to tremendous cold and high pressure, does not mean little life because many species are found here that are adapted to eating a dependable food source – the dead material that sifts down to the sea bed from above. Sea cucumber is one of many deep-sea species that mines dead organic particles from the sea floor for food. They have slow metabolisms and therefore do not require much food, sometimes only once a year and can live 100 years or more. There is a big difference if dead material is poisoned or had died from biological reasons. The special communities are present in the mid-ocean ridges, but they are more important for research of new possible biological or pharmaceutical importance than for food or feed because their existence is independent of sunlight.

Conclusions

Even under ideal institutional conditions the sea is not an inexhaustible provider of food, so we must be careful and not ignore geographical differences in population and income growth as well as effects of these different rates of growth on world fishery products.

The balance and equilibrium of the marine ecosystem cannot be radically perturbed. We will need more and more information to evaluate the real possibilities of sustained increases in yield in marine aquaculture. Dredging and deep-sea mining will disrupt coastal and oceanic ecosystems. Industrial, agricultural, domestic and energy-related pollutants will adversely affect biological productivity in coastal waters and interfere with aquaculture. Continued deforestation will lead to destructive silt deposition on coastal shelves. Coastal zones everywhere will be affected in one or another way.

It is obvious that pesticides reduce crop losses from pests and reduce contamination of the food supply with dangerous microorganisms and the toxins they produce, but it is also truth that only 1% of used agrochemicals reach the place where they have to be used. Most of such compounds are washed out with the rains and present non-point sources that influence the ocean food quality. Residues, from the old technology in the coastal region of several undeveloped countries, discharged in the rivers or directly to the ocean, still increase current level of impurities and it will continue for several decades in the future. It is only a question of *when* the ocean food sources will become uneatable, like the food sources from some rivers or lakes in Europe already are? Therefore in the future we need healthy and productive marine environment, and we look for a further development in new technologies.

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Knowledge Economy in Technical System with high Capital Value[1]

Abstract

With the application of knowledge economy postulate, as a new concept of value creation, the results of achieving the required level of competences of basic resources are shown, as condition for reaching the market competitiveness of the complex shipbuilding business-production system.

Based on a new process approach, the conceptual model used for measuring the value creation efficiency of fundamental resources and the knowledge economy in technical system with high capital value is represented.

By applying of "Learning Organization" and the "Value Creation Efficiency Analysis-VAIC™", a software tool developed to measure "Intellectual Capital Efficiency" is discussed.

Beside the basic postulate of "Idea management" in the work the result of continuous process improvement by the use of KVP^2 and SYCAT methods are shown.

The applied approach and methods enable research, examination and intellectual ability of shipbuilding business-production system.

Key words

New value creation, intellectual capital, process approach, shipbuilding

[1] Lecture presented at *Colloquium: Knowledge-Based Croatia – a Possible Contributions of the Croatian Scientists*, February 28, 2006, Zagreb, Croatia.

Introduction

Each business-production system's objective is an efficient use of existing potentials and the creation of a synergic effect, resulting in the quality products and services, and a raise of its value and the competitiveness of the system.

The quality of products and services is determined by the degree of incorporated knowledge and creativity into these products and services. That relates especially to business-production systems exposed to the international market, and thus forced to introduce modern approaches and methods of systems performance as well as measurement of value creation (value added) at all levels of business performance (Drucker, 1995).

Due to its characteristics and characteristics of its final product, the shipbuilding industry is considered a complex business-production system. The complexity of that system comes primarily from the complexity of many internal and external causal interactions of all the processes inside the system, but also from interactions of the system and the processes in its surroundings. Research has proved that value is created in both, internal and external processes, but in some parts of those processes value is also destroyed.

The application of modern approaches and methods in shipbuilding – which is the subject of this article – was highly influenced by the modern definition of a ship. According to that definition, a ship is a technical system with high level of information and automation and a high capital value. Due to its specific conditions of exploitation, it is subject to very rigorous tests of quality. Modern shipbuilding requires technologically propulsive preparation and production that also influences the development of the stakeholders and requires application of a complementary development model as a condition for breakthrough on the global market. That creates conditions for a rational enterprise and creation of wealth (Tominović, 2000).

Value added is measured by business results, the quantity of knowledge and quality of information incorporated in the product. The newly created value added also incorporates the work of human capital, and thus raises the company's market value. Leveraging the market value of a company or a system, value creation, value creation efficiency, assessment of the real value of the business production system, which includes also intellectual capital – these are the basic issues and concerns of contemporary business reality.

New terms have to be introduced to contemporary shipbuilding: intangible assets, intellectual capital, knowledge management, overall development of business relations, customer satisfaction, or briefly, the new economy.

Answers to the above problems, demonstrated on the example of a specific business production system (shipyard), and are closely related to following terms, contents and solutions to: measurement of “intellectual capital efficiency”, value creating working environment, working and communication culture, transfer and application of new knowledge. All this implies application of the ‘Learning Organization’ concept, with all its disciplines.

2. Basic Conditions for the Application of the “‘Learning Organization” and the “Value Creation Efficiency Analysis”

Applying new approaches and methods is not easy, in spite of the remarkable efforts of some individuals. First of all, it is necessary to recognize all the potentials of the basic structures of the system, which interact and thus make the system work. Those basic structures can be divided into creative, symbolic and physical ones; whereby the managerial structure is the one providing cohesion, connecting and aligning through its programs and decisions towards a defined strategic goal that is measurable.

The potentials and the knowledge incorporated in the basic structures can be recognized at a certain level of generalization. Thereafter a base for appropriate measuring systems has to be found, and then, by measuring intellectual capital efficiency, useful knowledge is to be highlighted and applied to create value.

Chosen Approach

The basic concept of the chosen approach comes from the consistent application of the “systems theory and process approach”**,** with an accent on rational performance of business processes and technology, including the ‘Learning Organization’ concept and its five disciplines. The term ‘business technology’ includes the way in which processes interconnect, the mode and order of their confrontation and the conditions of their procedure. The effectiveness of the procedure of processes affects the effectiveness of business technology, and also the effectiveness of the ‘Learning Organization' approach. Basically, the focus is on the proper transfer, application and creation of new knowledge (Senge, 2001).

The Process of Transfer, Application and Creation of New Knowledge

The process of knowledge transfer from nearer and wider surroundings consists of five phases, with built-in managerial and verification interactions. Each phase is a sub-process with inputs, activities, resources and outputs (results). Each output is verified from the professional point of view and documented with regard to quality, working culture and established communication rules (Tominović, 2000).

In professional problem solving, the optimal solution is searched for through teamwork. The optimal solution is the best one provided by an expert team in given circumstances.

The language used by the experts is a specific one, different from the managerial terminology. It is important to have that in mind when defining the job and scope of accountability of the experts in finding optimal solutions, as well as defining the managers' job and accountability of running the processes in which the solutions will be realized. In contrary, conflicts between these groups can easily happen due to the different language and overlapping responsibility (like rejection of good solutions or acceptance of bad ones). Differentiations of the above, and precise identification of parameters for dynamical measurement, enable control and alignment of intellectual capital. A suitable organizational model is vital in order to activate the existing intellectual potential (North, 1998).

The Model of Organizational Structure

Based on an analyses of business efficiency and effectiveness of complex business-production systems at the shipyard resulted in the conclusion, that the current systems were not optimally structured and thus do not achieve the expected synergic effect. A synergic effect can be divided into technological, managerial and psychological effects. The analysis also implied that the existing managerial structure should be redefined in alignment with some up to date global model, and also the necessity of catching up trends in IT development as well as the development of knowledge as a determining factor in the most developed and, thus, key systems (Binner, 2004).

Analysis of complex business-production systems of the shipyard implies that linear (hierarchical) and matrix structure are not suitable for dynamical measurements of intellectual capital efficiency. The former because of insufficient lateral communication, the latter due to conflicts at the point of realization, occurring at the crossroads between the "vertical and horizontal" line due to differences in knowledge application of the 'Learning Organization' and non-synchronized decisions of two professional and organizational structures.

The most suitable model in this case is an organization of interconnected fields or levels known as Hypertext Organization. It is based on a linear organization as a new structure of internal business systems, on a project team layer, and a knowledge-based layer. This knowledge-based layer will be referred to as "connecting structure".

The knowledge-based layer, being the key structure for knowledge transfer, together with the project team layer, represents the non-hierarchical structures usually created at higher levels of working culture and business technology.

From the process and product point of view, ship is a complex product (Figure 1), so it can be seen, that after identification and transfer of

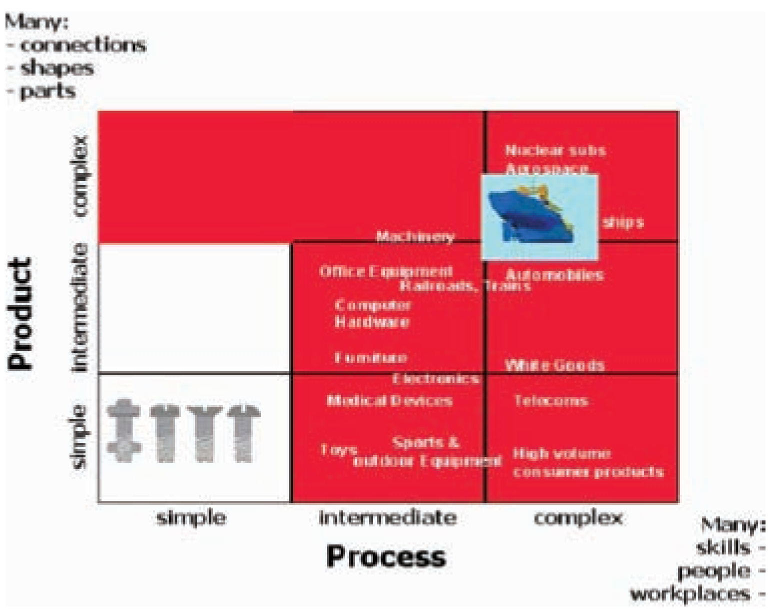

Figure 1. Ship as a complex product

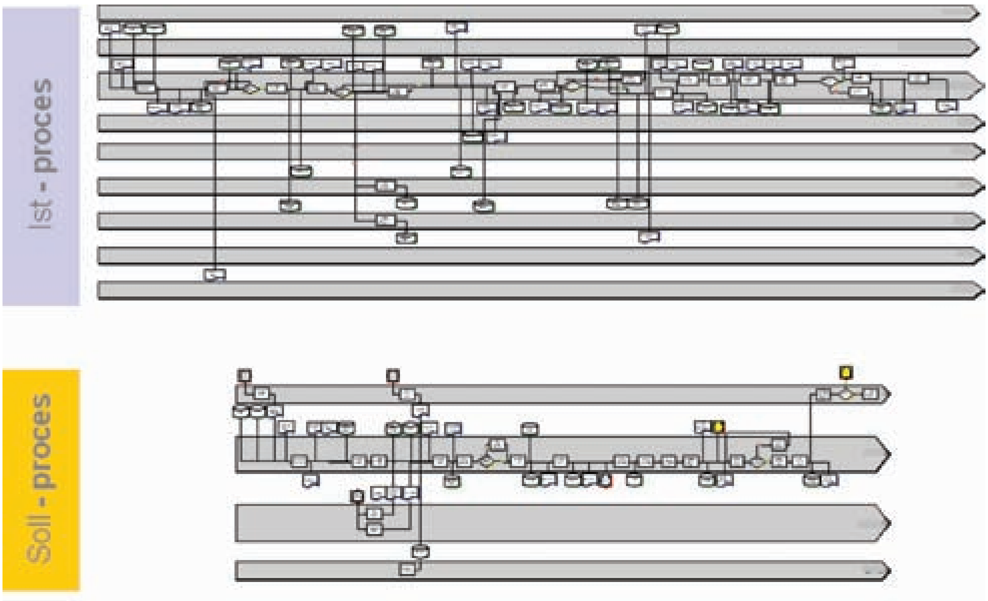

Figure 2. The optimization of processes

knowledge into the system, project teams begin to search for optimal solutions (Figure 2). Members of those teams create a hyper-communication and interaction network.

The number of interactions grows in line with the number of project teams, so that the non-hierarchical teams begin to introduce a new organizational form: the spider-web organization.

The network of teams interconnected with numerous information interactions, what points to the inner complexity of the observed business production system. This complexity is more than formal: solutions of different teams strongly interact and thus influence each other (cause and effect). This is why the structure of teams is cross functional (technology, planning, finance…)

The Learning Organization Concept

In this case, the Learning Organization Concept was based on a well defined vision. Created mission statement and measurable strategic goals were worked out by joint efforts of the entire managerial structure. After defining vision and an according mission, a program for the education of management (time limit) was worked out, which was to be the base for the realization of the "Learning Organization" Concept? The Program included the application of the Learning Organization Concept at all management levels. The term 'Learning Organization' implies an "organizations in which people continually develop their abilities to create results they truly desire, in which new ways of thinking are developed, in which individual and shared aspirations are freely stated, in which people continuously learn how to learn together," or, in short, "organizations that constantly increase their ability of creating their future" (Senge, 2001).

The "Learning Organization Concept" is based on the notion that learning is a process of competence development through experiences gained in applying certain methods.

Experience has shown that we are dealing with a process here (taking at least three to five years), requiring lots of persistency and systematic efforts during the realization period. The process of acquiring and applying new knowledge and skills is constant and perpetual. It is simply explainable: the environment changes unendingly because the process of learning is constant – from vision to reality, from reality to a new vision.

The realization of the "Learning Organization Concept" happened partly through suitable programs enhancing the development of new knowledge and skills of strategic management through a tailored postgraduate study. The same program was studied by tactical, and also operational management, but with changes so that it would be understandable for each managerial level. In this way a holistic approach of the learning process was achieved and new management and other professional knowledge was gained, talking about applicable knowledge, which could be transformed in new value.

3. Implementation of the "Value Creation Efficiency Analysis"

VAIC^{TM} – is a new management and controlling tool, designed as an IT support system, that helps management to monitor the performance of basic resources, like financial and intellectual capital. The implementation consists of six steps (Pulić, 2005).

1st step – calculating Value Added

$$VA = OUT - IN$$

OUT – total sales
IN – costs, i.e. everything that enters the company (expenses for goods and services purchased from third parties); labour expenses not included
VA – Value Added (includes also work in a company)

Value Added is the difference between total revenues and total costs needed for value creation in a certain period.

$$VA = OP + EC + D + A$$

OP – operating profit
EC – employee costs
D – depreciation
A – amortization

2nd step – calculating Human Capital Efficiency coefficient

$$VA/HC = HCE$$

HC – Human Capital (expressed with labour expenses)
HCE – Human Capital Efficiency

Human Capital Efficiency indicates how much new value has been created with one monetary unit invested in employees.

3rd step – calculating Structural Capital Efficiency coefficient

$$SC/VA = SCE$$

SC – Structural Capital
SCE – Structural Capital Efficiency

Structural Capital Efficiency provides information on the fraction of Structural Capital in Value Added.

4^{th} step – calculating Intellectual Capital Efficiency coefficient

$$ICE = HCE + SCE$$

ICE – Intellectual Capital Efficiency

5^{th} step – calculating Capital Employed Efficiency coefficient

$$VA/CE = CEE$$

CE – Capital Employed (physical and financial resources)

CEE – Capital Employed Efficiency

Capital Employed Efficiency indicates how much new value has been created with one monetary unit of financial and physical capital, in other words how efficiently the tangible resources have been used.

6^{th} step – calculating the overall efficiency in a company coefficient

$$VAIC^{TM} = ICE + CEE$$

VAIC™ – Value Added Intellectual Coefficient

VAIC™ indicates the overall Efficiency of key resources: financial and intellectual (human and structural) capital.

Figure 3 illustrates the results of the case study made on Croatian shipyard Uljanik from 2000-2005.

The case study indicates that by applying the concept of intellectual capital, combined with the application of the VAIC™ methodology – which helps to visualise the intellectual ability of the whole system and the processes – as well as by using the knowledge, the talent and the creativity of employees, it has been possible to achieve continuous improvement of business results (Tominović, 2005).

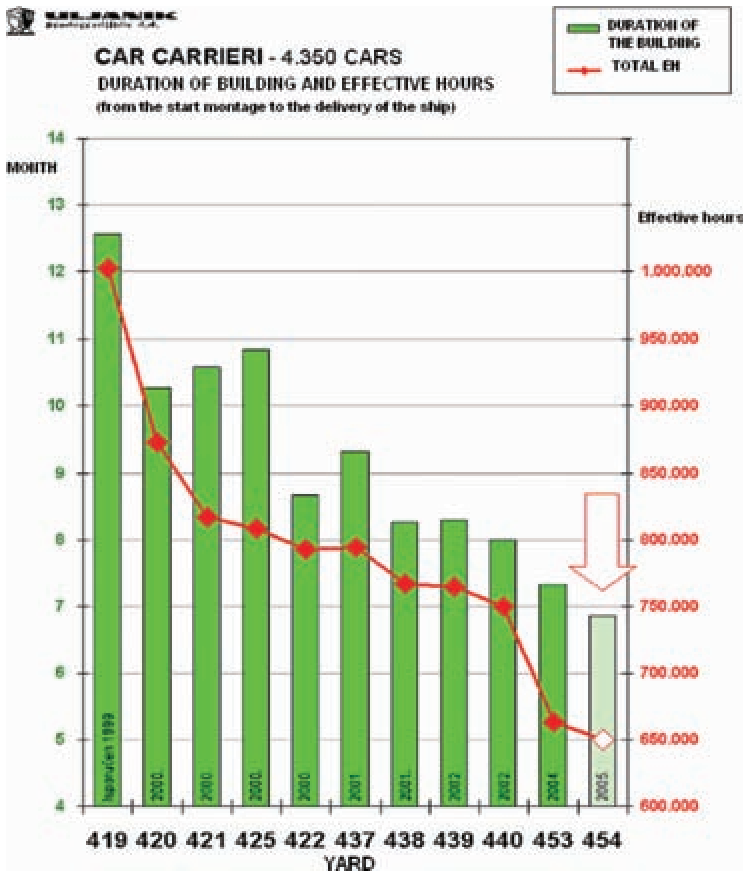

Figure 3. Experience Shipyard Uljanik

Benchmarking with a "Best in Class Company"

A complete picture of Efficiency and the real meaning of the indicated results are only possible through comparison to another company. The best-in class company in this case, is a leading shipbuilder in Europe.

Benchmarking focused on:

- Best-practice company, shipyard, or a complex shipbuilding system,
- Competitors,
- Companies existing in the economic system of the analyzed company,
- Members or profit centres inside a group of companies.

The total process of building a ship requires a lot of time. In order to apply this measurement tool as well as benchmarking, it was necessary to make preparation at:

- Organizational units,
- Basic preparation phases of shipbuilding production and building the ship,
- Business processes of the shipyard,
- Other segments of the virtual shipbuilding system (internal and external parts of the system), wherever it is possible to define revenues and costs.

It is assumed that the shipyard has successfully captivated the basic concepts of the Learning Organization and Cost management (in the processes of preparation and production). In this case, that means really knowing the skills of running the entire process and knowing the structure of expenses for every phase or business process.

4. Conclusion

There are many different opinions, even controversies, about the true value of particular business-production systems. Evaluation, based on traditional indicators only, could lead to wrong conclusions and consequently, wrong decisions, especially if the system has a specific know-how. Estimates are possible thanks to new indicators and new methods of measuring non-tangible values such as intellectual capital.

Intellectual capital is being created in processes inside the system and its value creation can be measured with the help of modern measurement tools. The VAIC™ Method was found to be the most appropriate for our circumstances. This method can quickly indicate the value creation efficiency of intellectual capital on company level or, inside of its organizational units, for any time period (only if necessary data is available).

However, for companies with longer tracked periods, especially if the number of internal and external interactions (where value can be created or destroyed) is large, it is vital to measure basic processes. That requires a deep understanding of how these processes function and also defining the intensity and interdependency of interactions inside the system. It is an especially difficult task to make the system transparent and therefore measurable.

One of the ways of solving this problem is the application of the Learning Organization concept with all its disciplines in combination with an adequate organizational model, which enhances the creative potentials of characteristic structures that exist and act in business-production systems.

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The Role of Knowledge and Highly Educated Personnel in the Relocation of JADRAN Hosiery Factory Plc.[1]

Abstract

JADRAN hosiery factory plc. of Zagreb relocated twice in relatively short period of time. Both relocations indicated the extreme significance of knowledge and highly educated personnel in that kind of projects. This was particularly evident during the second relocation which was essential for factory's survival.

Key words

Factory relocation, production of pantyhose and socks, role of knowledge

1. Introduction

JADRAN hosiery factory was founded in 1929/30 and started its operation at the location in Zagreb, Supilova 7. Since that time JADRAN has been producing panty hoses, socks, stockings and socks for children always applying state-of-the-art technologies of that particular time [1, 2].

[1] Lecture presented at *Colloquium: Knowledge-Based Croatia – a Possible Contributions of the Croatian Scientists*, February 28, 2006, Zagreb, Croatia.

Nowadays JADRAN is the only “living” factory of that time and the oldest hosiery factory in this territory.

The factory remained in Supilova Street for nearly 60 years until 1991 when it moved to Rapska street 52 in Zagreb, where it merged with ZORA, a woollen fabrics factory.

In 2004 JADRAN relocated again from Rapska to larger production facilities at Vinka Žganeca br. 2, Zagreb.

These relocation projects were complex and demanding because the entire factory was to be moved and production restarted or continued at a new location. Both relocations served in this paper as the basis for analysis and comparison as to the extent and importance of knowledge and highly educated personnel in these demanding operations.

2. First relocation

Over the years JADRAN has expended its business, enlarged its machinery in operation and production quantity, due to which premises in Supilova Street proved too small and inadequate for growing demands (Fig. 1). The total factory used area amounted to 3223 m^2. It was the shortage of the factory space in Supilova Street that forced JADRAN to find out an adequate solution that will enable production constant growth and meet business goals. The solution was the move to Rapska Street into the premises of ZORA, a woollen fabrics factory (Fig. 2).

Figure 1. Hosiery production in Supilova 7

Figure 2. Main entrance in Rapska 52

At the time of first relocation (from Supilova to Rapska) the factory moved into production space in which weaving machines were installed. Accordingly, the entire infrastructure at this location was adjusted to the fabric production. Therefore the old machinery had to be decommissioned and dismantled, a new space adequately rebuilt and the entire hosiery production plant moved from Supilova Street.

The relocation was organised and carried out by technical staff and management, mostly highly qualified and qualified technical personnel employed in the factory at that time. The works were performed according to their experience and technical knowledge, having no professionally drawn up plans and projects. Since there were no strategic plans, and decisions were supposedly made in a very short time, studies on production technology, organisation of production and work as well as feasibility study on that kind of production organisation were not developed.

It took 12 months to relocate the factory. It is to assume, according to unofficial information, that this move was expensive and uneconomical.

Having moved to Rapska Street, production facilities were organised in 8 halls of 8000 square meter space. The production was divided into operation units: **hosiery knitting** (toe sewing machines, sewing automats and control and inspection equipment), **sock knitting** (sewing, chaining, control), **thermal finishing** (dying unit, laboratory, forming – ironing, drying), **final finishing** (packaging machines, manual packaging, warehouse) (Fig. 3, 4). There were altogether 500 machines, aggregates and devices grouped according to certain production phases and operated by 420 employees.

Figure 3. Hosiery knitting

Figure 4. Thermal finishing

However, the relocation of the factory didn't bring expected results. Although new premises provided a far greater space, the technological process was adjusted to the space which caused various problems. The production organisation was rather bad resulting in the increased inner transport, intermediate product warehouses, thereby requiring an increased number of personnel. The existing building and halls built before the World War II, along with the belonging infrastructure, were dilapidated by use. Working conditions were poor, most of all ventilation, heating and cooling.

Therefore it was necessary to develop and prepare a new strategy for JADRAN's survival.

3. Second relocation

A new strategy for JADRAN hosiery factory plc. comprised of 4R's (**R**estructuring, **R**elocation, **R**edesign and **R**epositioning).

In line with that strategy a new, very attractive and nice location was found at Vinka Žganeca 2 in Dubrava, Zagreb. This new site encompasses a 14.500 square meter plot area and 10.000 square meter building area consisting of the ground floor and two stories. The building was erected in 1987 for the needs of the factory Nikola Tesla. Since the building was not in use and not occupied it was ready to be slightly rebuild and adapted for the purpose of JADRAN production (Fig. 5).

The starting point for relocation project elaboration was a past experience in factory relocation from Supilova to Rapska in 1991. The plan was drawn up by factory's professional staff and management. The first draft comprised of a schedule offering and anticipating a 12-month deadline, possibly shortened to 8 months. Since the setting of the schedule and the deadline was of crucial importance, affecting even the very survival of the factory, the new factory management could not accept this schedule for both economic and organisational reasons. It was concluded after long discussions that the existing staff structure was not able to grasp the basics of the problem differently.

Therefore a new team was formed consisting mainly of highly educated personnel (Tab. 1). This new team draw up a new relocation plan, provided guidelines and explained all necessary details to the operative team (team for physical relocation) about its part in the relocation activities.

Table 1. Education and qualification structure of JADRAN hosiery factory plc.

Factory's management	Qualification	
	1990	2004
Director	VŠS	VSS
Technical director	VKV	VSS
Team manager	VKV	VSS
Head of the operative group	VKV	VKV/VSS

Legend:
VSS = university degree, VŠS = higher qualification, VKV = vocational qualification

The planning in respect of layout and placement of machines according to technological process was assigned to several external collaborators being professors and collaborators of the Faculty of Textile Technology. "Feasibility study of the relocation of JADRAN hosiery factory plc." was assigned to a company specialised in that kind of projects [3]. This company tailored in cooperation with the factory management a document that proved undoubtedly the justifiability of the planned activities.

This project ensured maximal rationalisation of activities and certain steps, and decreased unnecessary downtime, decreased inner transport, resulting in rationalisation of the number of workers engaged.

The relocation project encompassed preparatory construction works and relocation of machinery.

The rebuilding of new premises commenced on April 1st 2005 and was performed by both own personnel and specialised companies. Some major changes in building design were done in order to place dying machines in the basement, electrical installations, and new water supply installations (soft and hard water) were reinstalled, a new boiler room for steam production was erected and a new gas connection provided. In addition, new toilet facilities were refurbished, new closet cabinets mounted, and offices rebuilt.

It should also be mentioned that during the pre-move planning a special care was taken of the environment protection and energy saving solutions so that a wastewater purification unit applying membrane separa-

Figure 5. New building

Figure 6. Wastewater purification

tion technique of reverse osmosis was installed (Fig. 6). This unit recycles wastewater that can be fully reused in the technological process of hosiery treatment and finishing.

The moving of machines started on July 1st 2004 and ended with the production restart on August 16th 2004. All production phases and units were in operation at the old location prior to the relocation and moved within the said time period minimizing downtime of particular production phases to 4 weeks. The relocation was planned and carried out during vacation close-down so that no working days were lost. For this reason, the production fulfilled its plan for the year 2004. Stipulated business deals with domestic customers and contracted quantities for export did not allow any default of delivery as these products are seasonal products that are worth little once a season is over and almost nobody wants them at the end of the season.

The relocation of the factory was very demanding because more than 500 machines and appliances had to be moved and put in operation (Fig. 7). It was especially hard to move very voluminous and heavy machines for thermal treatment (dying and ironing machines) the operation of which required utilities supply connections (Fig. 8).

The sequence of relocation activities, the beginning and the final stage of relocation were determined by the production process. Therefore the relocation of the factory was executed sequentially according to the production phases: knitting and sewing machines of the production unit I (so called thick programme of men and children socks) were moved first, than knitting and sewing machines of the production unit II (so called hosiery programme) after that packaging machines and finally thermal

Figure 7. Moving of sewing automats

Figure 8. Thermal treatment

treatment (dying and ironing machines). It should be pointed out that the relocation activities were carried out by factory's personnel which is praiseworthy since restart of the factory encountered no difficulties.

4. Summary

Since these two relocations of JADRAN hosiery factory plc. were executed in a rather short period of time, they have served well as the basis for analysis and comparison, and showed as to which extant the role of knowledge was crucial for factory's further development.

The aim of the first relocation was to move the factory to a larger production facility. This move was performed without any pre-move plan or project or feasibility study either. Insufficient care was taken of the possible consequences resulting from the inadequate premises.

On the occasion of the second relocation the role of knowledge and highly education personnel became prominent. Production layout and placement of machines as per technological process were well considered and planned in detail, whereby particular activities were rationalized, downtime and idling minimized, inner transport improved, and finally, a better organisation of work and rationalization of the number of workers employed achieved. In line with the latest trends considerable care has been taken aiming at protection of the environment.

The second relocation ensured factory's future and prosperity, because new, suitable factory premises and well organised technological process provided greater flexibility in responding to the growing demands form customers. Due to these new conditions the management could proceed with the restructuring process.

The relocation of JADRAN hosiery factory plc. showed that knowledge and personnel played a crucial role not only for factory benefits and progress but for society at large.

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ComVis©
Interactive Data Visualization Tool[1]

Abstract

ComVis© is the interactive tool for data visualization that enables improved and faster data-based reasoning. ComVis© significantly improves data comprehension by speeding up the comprehension process and enabling the intuitive ways of reach, selection and research of data by:

- *Creating data images*
- *Interactively visualizing large quantity of data*
- *Simplifying the analysis process*
- *Ensuring visual recognition of data interdependence*
- *Enticing creative thinking*
- *Enabling fast reasoning*

Traditional report methods and technologies are static, allowing minimum data interaction. ComVis©, as a representative of new generation of solutions, enables direct interaction with dynamic data and images mutually connected, providing numerous possibilities and ways of comprehending new information drawn from the existing systems.

ComVis© is used:

- *When processing large quantity of data in a short time period*
- *At independent distribution of questionnaires, without IT support*

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[1] Lecture presented at *Colloquium: Knowledge-Based Croatia – a Possible Contributions of the Croatian Scientists*, February 28, 2006, Zagreb, Croatia.

- *At comprehensive research of data, from different viewpoints*
- *When comparing different reports*

ComVis© enables improvement of business efficiency:

- *Discovering new business opportunities with visual investigation of technical, corporate and table data*
- *Ensuring time savings while producing graphic images and business reports*
- *Attaining clear communication of data that are the subject of research, displaying similarities / differences throughout the whole analysis*
- *Reducing time needed for first cognition, decision and action*
- *Decreasing gap between business and technical disciplines, using simple common analytic environment*
- *Developing interactive analysis based on monotonous data*

Target Business Areas

- *Business planning*
- *Sales and Marketing*
- *Finance*

Key words

Interactive visual data analysis, business planning, sales and marketing, finance

1. Introduction into ComVis©

ComVis© is the interactive computing tool for data visualization that enables effective method of research and comprehension of large quantity of information, without studying every single fact and its interdependences. User is able to perform interactive visual analysis of multidimensional data.

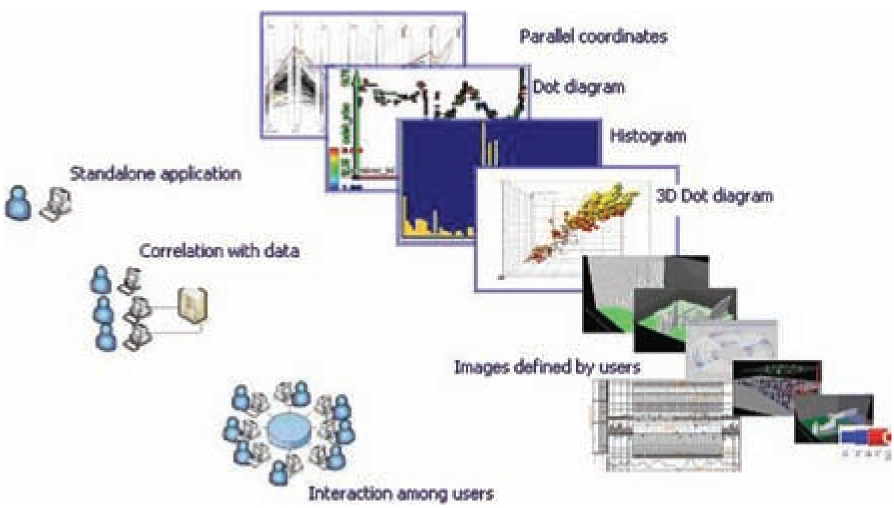
ComVis© helps discover trends in data and perform analysis of interdependence of complex data. Main factor of visualization is human perception. Converting data into images, we bring data closer to human capabilities of recognizing, perceiving and focusing, in order to simplify data comprehension and increase its efficiency.

The goal is to enable fast and unlimited access to the group of data through graphic objects that provide the basis for experimental research and conclusions.

Taking all of the above into consideration, ComVis© can, together with classic data mining and statistics, significantly speed up the analysis of complex data.

ComVis© enables:

1. Interactive Visual Data Mining
2. Improved layout of results – It creates data images
3. Momentary research of different aspects of information, which reduces the analysis process time
4. Presentation and visual recognition of data interdependence
5. Simple reach for information – ComVis© is, as a standalone application, integrated with the user's environment
6. Fast reasoning



It is important to mention that ComVis© does not require previous technical knowledge on information processing, which makes it simple to implement into new environment and to educate new users.

ComVis© helps in producing new knowledge about data and relationships, initiating further research, deepening insights of all the possibilities of data analyses, and at the same time, generating easily understood images of the present state.

The main difference between ComVis© and traditional report methods and technologies is that they are static, enabling little interaction with data.

On the contrary, ComVis© enables direct interaction with dynamic data and images that are mutually connected, providing various possibilities and ways of comprehending new information provided by the existing systems.

2. ComVis© and Today's Business Challenges

Being successful in business means one always has to be at least one step in front of the competition. Management has to make quick, high-risk, but at the same time, reliable business decisions in all situations – ranging from complex research to plain telephone calls.

Business environment is becoming increasingly aggressive and managers are under high pressure to run a successful business. Company owners demand high business results and fast profit quote achievements.

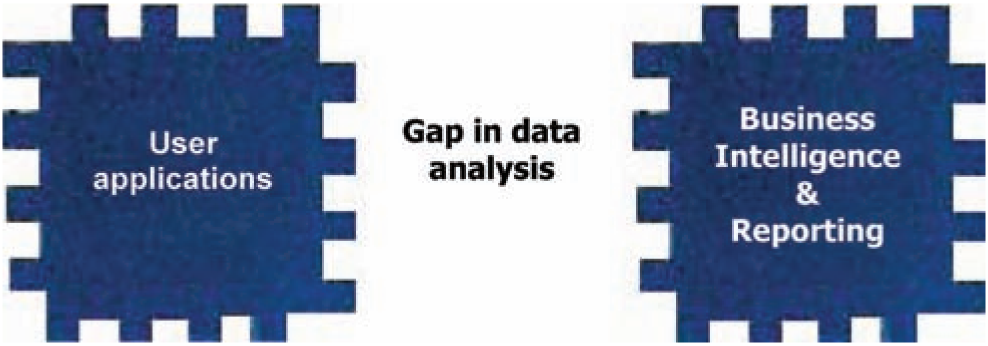
In different industries "time to profit" depends on time needed for:

- research;
- revenue achievement;
- capital turnover;
- decision-making.

We can draw a conclusion that TIME is one of the key factors in today's business. This is where ComVis© steps in. In the next two subchapters, we will shortly describe the previous and present situation in data analysis technology.

2.1 Previous Situation in Data Analysis Technology

Before we make any business decisions, we must perform data analysis and obtain conclusions that would help us make the right decisions. The main drawback of previously available data analysis technology is that it did not reflect changes in trends that were happening from the moment of the initial analysis of the market situation.



Standard software tools do not provide a solution:

- They are too slow and too expensive.
- They cannot process large quantity of data.
- They provide reports based on predefined, obsolete inquiries.
- They cannot present data graphically in real-time and interactively manage the images.
- They cannot graphically show the interdependences of different data images drawn from the same data set.

2.2 Present Situation (with ComVis©)

Today, information is the basis of business. Right information obtained at the right time is the basis for successful decision-making, and consequently, for further business development.

Information management is developing and improving rapidly, following the needs of the market. Combis took part in its path of development.

Recognizing needs of the clients, Combis has been working closely on development of ComVis©, interactive data visualization tool, with Dr.sci. Krešimir Matković (from the company VRVis – Virtual Reality and Visualization), who has been actively researching science visualization for years:

- Dr.sci. Matković is the main researcher and leader of the group for science visualization in research center VRVis in Vienna.
- He is the project manager of three-year-long projects:
  - "CFD and Multibody Visualization" and "Multidisciplinary Modeling and Visualization". In those projects, he has been cooperating very

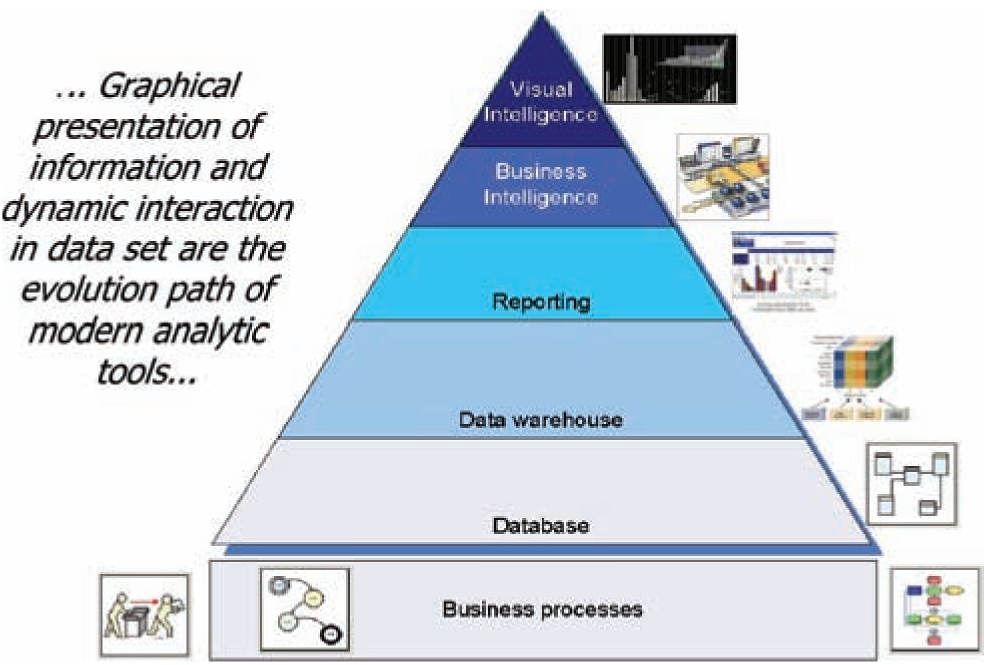
closely with AVL, on of the biggest companies in the area of simulation of internal-combustion engines.

– "Non-Intrusive User Interface Devices" and "High Throughput User Interfaces", in which he investigates unconventional user interfaces based on virtual reality, as well as "Tangible user interfaces".

- He is also the project manager of two 4-year-long projects in the area of visualization and virtual reality.
- He is the "Research Assistant" at the "Institute of Computer Graphics and Algorithms, Vienna University of Technology".

Combis and VRVis have formed joint development team that started to work on the project in August 2004. In February 2005 it underwent testing in Zagreb and Vienna. The real testing was a trial project in large Croatian bank that was completed successfully. The first public presentation was held at Microsoft conference – Windays 2005 in Opatija, Croatia.

Our goal was to provide clients with a solution that would facilitate and improve their business, enabling them to obtain complete power over data management. ComVis© converts business information into image objects that we can more easily understand

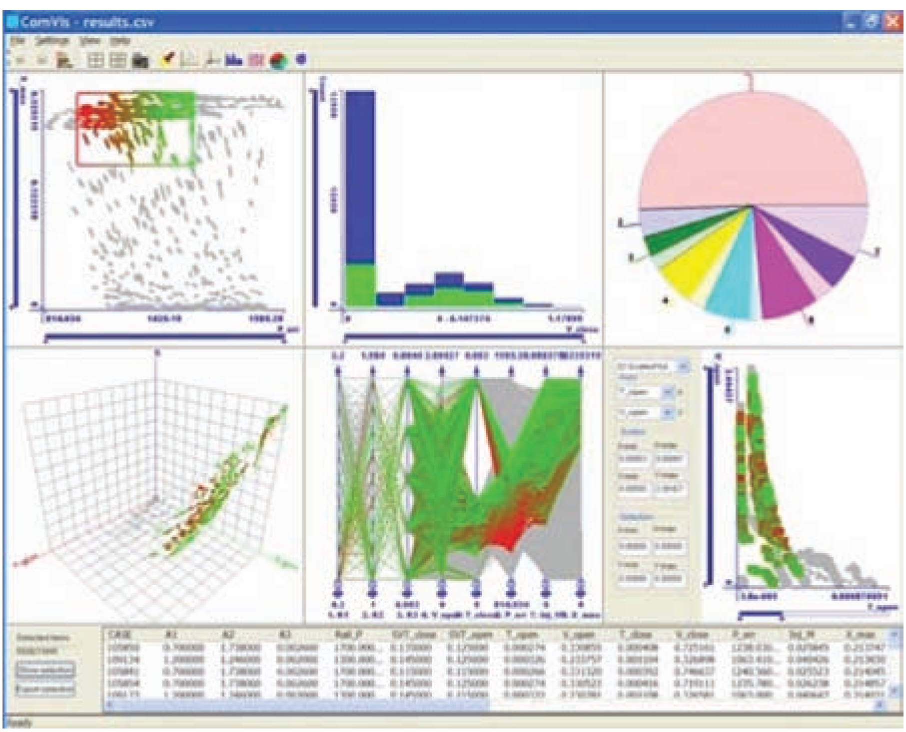


ComVis© Basic Tool

- MS Visual C++
- MFC + OpenGL
- Data Management
- Input: csv
- Output: csv, bmp

The most common presentation techniques are:

- 2D and 3D histogram
- 2D and 3D diagram with dots
- Parallel coordinates
- Spiral
- Pie
- Curves
- User defined



3. Target Business Areas

Business areas where ComVis© can especially contribute to performance improvement are:

- Business Planning
- Sales and Marketing
- Finance

3.1 Business Planning

- **ComVis**© helps financial planners and management identify trends and opportunities related to reallocation of resources, investments and production planning.

3.2 Sales and Marketing

ComVis© helps:

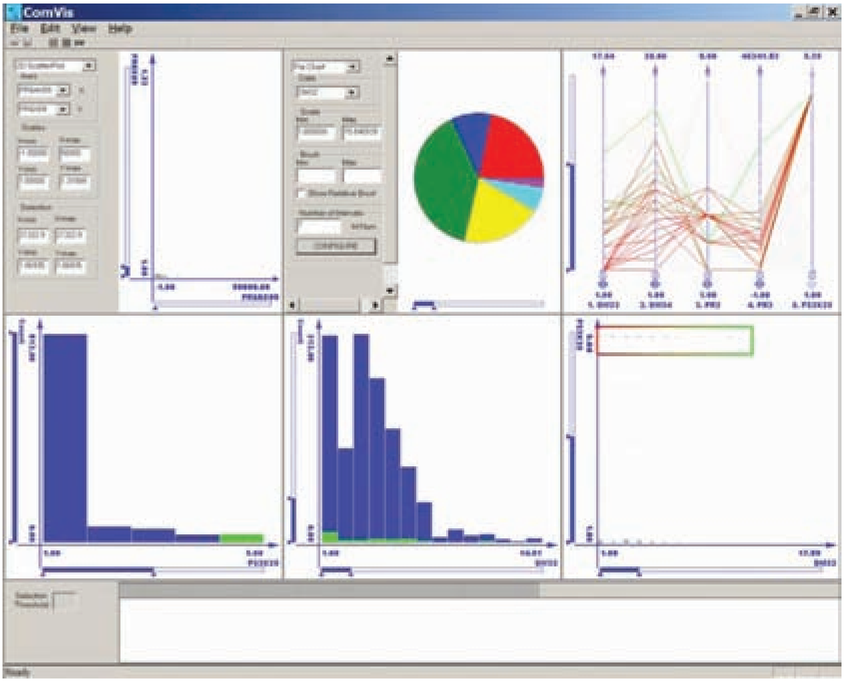
- Sales management analyze and improve sales processes and the effectiveness of the sales channels, with the aim of increasing return on investment and market share;
- Marketing department understand client behavior, market development and trends, in order to maximize the effectiveness of marketing campaigns and increase client loyalty.

3.3 Finance

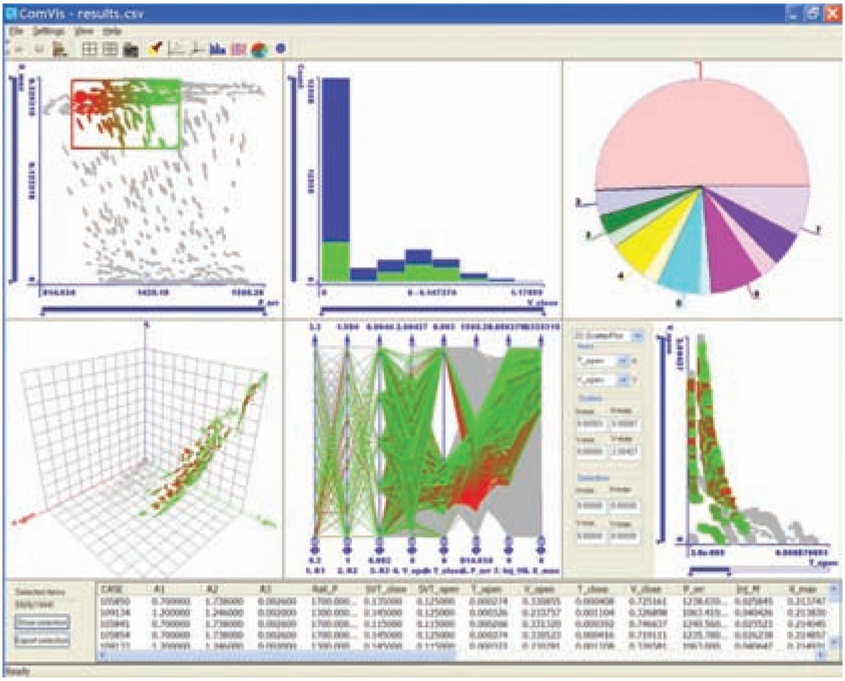
- **ComVis**© helps financial management at fast data search, enabling identification of crucial information and control over financial transactions. Thus, ComVis© helps improve coordination with the legislative and increase operational efficiency.

4. Advantages of ComVis©

ComVis© functions as a standalone application, adjustable to all data sources. It can be integrated with user's infrastructure and databases, being able to reach data from different data sources, enabling complex data analysis.



Visually defined questions – Visual answers



Data format in main ComVis© version is ASCII format, available to everyone, which allows fast start with the application.

Another advantage is that foreknowledge of data is not necessary.

Being aware that **time and fast reaction to the market** is crucial in leading a successful business, we have developed a solution that supports main issues of our customers:

Visualization of the information ensures:

- Presentation of complex and (or) numerous data
- Interaction in real time

With the purpose of:

- Recognizing data interdependence
- Fast pattern observation
- Creating data knowledge

ComVis© helps maximize business effectiveness by:

- Providing additional information about a group of data and enabling simple data export
- Discovering new business opportunities with visual investigation of technical, corporate and table data
- Ensuring time savings while producing graphic images and business reports
- Attaining clear data communication that are the subject of research, displaying similarities/differences throughout the whole analysis
- Reducing time needed for first cognition, decision and action
- Decreasing gap between business and technical disciplines, using simple common analytic environment
- Developing interactive analysis based on monotonous data

We have reached our goal:
to fill up the gap in data analysis,
which is the key step in providing dynamic visual information.

5. ComVis© – Next Steps in short

1. Further technological development

We will work on:

- enabling multiple selections over groups of data, with users being able to define logical operations:
- developing connectors on mainstream databases;
- improving algorithm;
- providing opportunity to work with even larger quantity of data;
- enabling parallel data presentations in multiple windows that are open at the same time

2. Marketing

We plan to:

- Create new distribution channel
- Distribute open source version of the main packet
- Work on stronger product promotion
- Organize specialized conferences
- Advertise in IT Magazines
- Hold presentations to clients
- Initiate pilot projects at larger accounts

3. Further product development

- We will provide functional packaging – for business areas that deal with large quantities of data:
  - Business Planning
  - Sales and Marketing
  - Finance
  - Controlling
- Business Consulting packages that we plan to provide will:
  - Enable easier introduction of new technology
  - Be focused primarily on business use

4. Expanding cooperation with VRVis team

We plan on using unconventional user interfaces in commercial IT projects and studying inspirational space for education based on unconventional user interfaces.

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Croata and Science[1]

The specific character of the successful development of the *Croata* brand and our business, founded in 1990, consists in the fact that our approach and brand are built on the premise of the values of the Croatian cultural identity and the self-awareness of successful creativity throughout the course of Croatian history. As a result, *Croata* is seen positively today as a specific, original step forward, not only in Croatia and Bosnia and Herzegovina but also at universities and scientific centers in several western countries (Spain, the Netherlands, the USA etc.). Marijan Bušić has fulfilled his youthful vision of Croatia as the *homeland of the cravat* and the cravat (or tie) as a special medium of communication, together with his friend and business partner Zlatko Penavić, in the company Potomac. The national brand *Croata*, with its range of top quality products (cravats, scarves, shawls, waistcoats, suits, accessories etc.) at the same time has passed the test of success on the world market. Even the very name of the company, Potomac, after the river of the same name that flows through Washington, testifies to its orientation towards the world, the desire to step out into the world.

Aware of the need to take contemporary development and world trends into consideration, Marijan Bušić and Zlatko Penavić sought inspiration in specific victorious experiences in Croatian history, and the Croatia's creative response, which was never lacking. We will mention just some of these experiences briefly. The specific Croatian military strategy used in

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[1] Lecture presented at *Colloquium: Knowledge-Based Croatia – a Possible Contributions of the Croatian Scientists*, February 28, 2006, Zagreb, Croatia.

the Homeland War, which was of vital importance for the victorious outcome, is being studied, as far as we have heard, in several world centers for the study of war strategy. The successful work in action of the Croatian light cavalry throughout history is also well known, with its specific tactics and strategy. Today it is interesting that Croatia, although relatively unknown, achieves some of the best results in world sport, and the specific Croatian manner of playing and winning is also mentioned. We could go on to talk about the skills of Croatian diplomats and Croatian businesses, and we should not overlook the successful experience of the Republic of Dubrovnik, which, although it covered only a small territory, squeezed between powerful empires, succeeded in developing and surviving over several centuries. The successful diplomatic and political model of the development of the Republic of Dubrovnik has been expressed in outstanding works of literature, culture and science. We cannot but mention the Vinodol Law Book, which in an extremely advanced manner systematized the legal conscience of the Croats in the Middle Ages, etc.

The result of this approach, in which we have recognized world trends and at the same time introduced Croatia's specific experience and advances, has enabled us to achieve the most difficult thing in business today – to develop a brand that is both national and worldwide. Through the *Croata* brand we have in fact presented Croatia as a brand to the whole world. Bringing together business and culture, in the symbolically very powerful and in cultural terms unavoidable medium of the tie, which symbolically represents the values of freedom and responsibility as the foundations of human civilization, we have presented Croatia to the world as *the Homeland of the Cravat*.

The successful development of the *Croata* brand, to date and in the future, is inconceivable without the successful

application of knowledge and science. Primarily, in the development strategy of the brand, we recognized the situation in the world and trends, but, as we have already pointed out, we relied to a major extent on the comparatively successful experience of Croatia to date. Secondly, in the growth and development of the company and the brand, from the very outset, experts were included with contributions from a wide variety of fields: experts and scholars in the field of architecture, design and fashion; historians and writers in analysis of the design of ties and scarves[2]; literary works were created on the subject of the tie and Croatia, such as *The Homeland of the Cravat*… Historians are researching the development of the tie in various historical periods, and sociologists and psychologists research the symbolic potential of the cravat, and the effects, which our projects, primarily the art installations by Marijan Bušić (The Cravat around the Arena, The Cravat around Croatia etc.) have on the public in Croatia and the world. Musicians, composers, artists and theatrical performers also contribute, through their original work, to the worldwide promotion of the *Croata* brand and Croatia as *the Homeland of the Cravat.*

The broadly conceived and fruitful collaboration of experts of various descriptions, who are involved in the development and promotion of the *Croata* brand, takes places within the cultural institution Academia Cravatica. Marijan Bušić founded this institution, the only one of its kind in the world, in 1997. Academia Cravatica researches the development and symbolic potential of the cravat, and promotes the cravat as a spe-

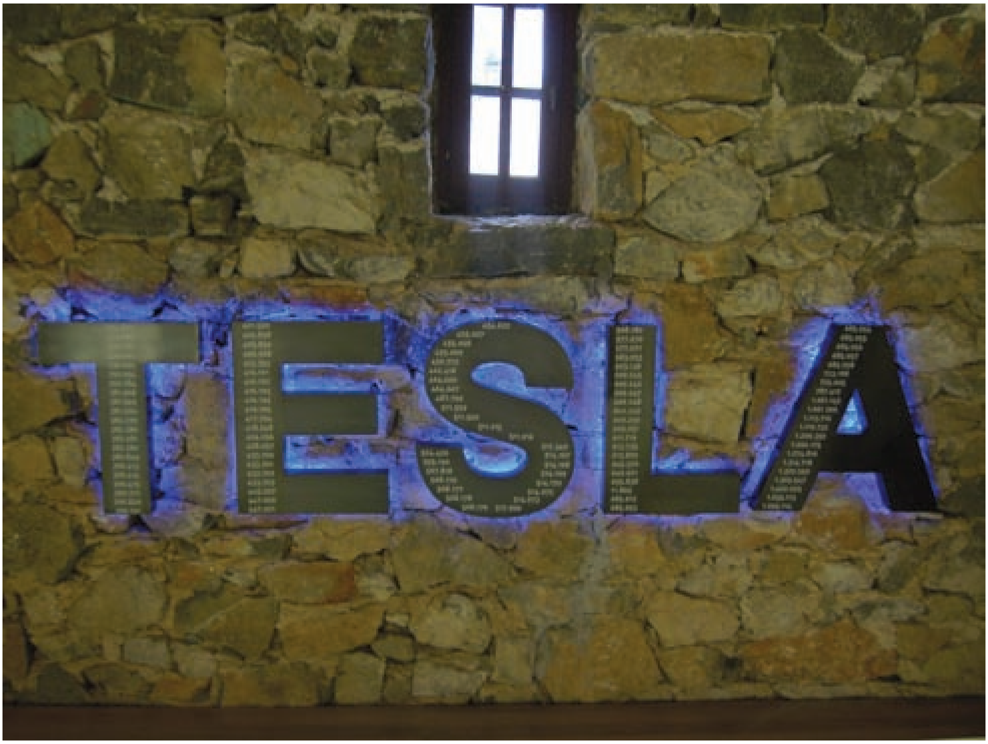
[2] There are about 150 literary and historical motifs of this kind, with essays based on historical fact, and they are an excellent cross section of the best contributions and creativity from Croatia's historical development to the present day. Historians also undertake complete historical research on the subject of the cravat (tie), for example on the Thirty Years War in the 17th century, when the cravat was first recognized as worn by Croatian soldiers.

cific medium of communication and part of the Croatian and world cultural heritage.

We would like to channel our experience in business and use of expertise and knowledge into the *Croata Business School*. We will offer new ways of thinking in business and evaluation, which will bring together and harmonize the best results in Croatia and the world. In so doing, our intention is not to offer a package of knowledge and ready-made solutions, but rather to enable individuals and businesses to achieve success in a business and wider social sense, by self-consciously making use of their own creative potential and know-how. Precisely in this process of enlightenment and activation of their own self-awareness and its creative power, lies the specific character and originality of our model. With the cravat (tie), which symbolically represents the unique identity of every individual human being, we want at the same time to present and affirm the value and identity of all the peoples of the world.

NIKOLA TESLA

150th Anniversary of the Birth



Detail from Tesla's house – foto by Z. Kniewald

International Scientific
and Professional Meeting

"The Life and Work of Nikola Tesla"

June 28 – 29, 2006, Zagreb, Croatia

President of the Croatian Parliament Vladimir Šeks

President of the Government Ivo Sanader, Ph.D.

Minister of Science,
Education and Sports
Prof. Dragan Primorac, Ph.D.

Stjepan Mesić
President of the Republic of Croatia

Opening speech of the President of the Republic of Croatia

Dear Members of the Croatian Academy of Engineering,
Dear Participants of the Symposium,
Ladies and Gentleman,

First, I would like to thank you for your invitation to the opening of this scientific and professional symposium on the life and work of Nikola Tesla.

I would also like to congratulate the organizer of the meeting – Croatian Academy of Engineering, for this symposium, together with other manifestations in the Year of Nikola Tesla, is going to refresh in a scientific and professional way well known facts about the life and work of Nikola Tesla, as well as explore some new ones. If we searched for an image to describe phenomenon of a genius in human history, then we could remember the poem by Cesarić, “The Cloud”. The poem is widely known: the cloud suddenly appears, unnoticed from beyond and stays unrevealed because the people are engaged in trivial affairs. Such is often the destiny of a genius, especially in small communities.

Nikola Tesla has partly experienced a destiny of non-recognition, mostly in his homeland. Namely, in the time, he had first displayed his genius; Croatia had not perceived those signs and had not recognized him. There are numerous reasons for that: from difficult political times by the end of 19th century, lack of adequate studies to poverty and administrative nearsightedness. Luckily, Tesla did not have to experience the fate of the Cesarić’s cloud that was swung and dispersed by the high wind. Having left for the New World, dynamically progressive at the time, he has found his place there and has become one of the greatest names in the world of physics, electrical engineering, power plants, automata theory, communications and other fields.

The person of Nikola Tesla is in the focus of interest primarily due to his genius and his contribution to the world science and engineering. If he had not achieved nothing else but the introduction of alternating current into wide usage, his name would be forever inscribed into the book of the most meritorious for the progress of human civilization. However, being aware of the fact that Tesla has invented or theoretically conceived almost all technical devices we are using today, that he formally started the second industrial revolution, then his role becomes immeasurable.

Apart from his ingeniousness, Tesla has displayed many virtues, which make him a true giant. First, he has had diligence, devotion, thoroughness, patience and perseverance to put his ideas to life. Furthermore, although single and often lonely, he has always been aware of the fact that every invention or action should be made to the benefit of the man and humanity. Above all, Tesla has been a moral person. He has helped many without pretensions and by far without taking advantage of his genius.

Although in his lifetime he has acquired fame and glory, he has never looked down upon to the others, but has kept his pride not allowing others to mock his ideas or to plagiarize them. To those, he used to say, "belongs the present, but the future belongs to me".

Nikola Tesla was a pacifist who looked upon his inventions as a means of progress, peace and co-operation among nations. Though deeply a cosmopolitan mind, he was proud of his Serbian kin and his Croatian homeland, as he wrote in his letter addressed to Vlatko Maček. He has not forgotten his homeland, Zagreb nor native Lika. Croatia has in time finally realized what a son it has had in far away America trying to pay him due respect.

Although he has not been involved in politics, Tesla's humanity and his sane patriotism are even today inspiring to all those seeking for models of coexistence, humanity and honesty in Croatia and abroad, as well as an example of how to serve their own country even when they live far away from it.

Commemorating the Year of Nikola Tesla, we shall have the opportunity on the 150th anniversary of his birth to express gratitude to his exquisite personality, to highlight his merits and unveil the memorials. Tesla himself once said: "Let the future be the judge and show the truth about my work and achievements. ".

Moreover, the future has already arbitrated. Although he has not received the Nobel Prize due to the envy of lesser people, it could be said, as someone has already done – that every electric pole is his monument!

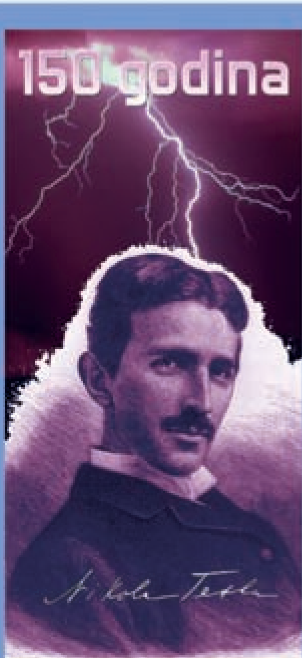
Hardly a greater honor has history shown to anyone. Today there is no need to either usurp or divide Tesla. His name is the world heritage, heritage without which the world would be more divided and even poorer. Croatia is happy that in her lap, in Smiljan in Lika, was born a man who has so much indebted the human race. I believe that this scientific and professional symposium will contribute to his brighter memory.

I declare the scientific and professional symposium on the life and work of Nikola Tesla open!

Thank you very much!

Stjepan Mesić
President of the Republic of Croatia

ZBORNIK RADOVA
PROCEEDINGS



MEĐUNARODNI
ZNANSTVENO-STRUČNI SKUP
"ŽIVOT I DJELO NIKOLE TESLE"
(28 – 29. LIPANJ 2006.)

INTERNATIONAL SCIENTIFIC
AND PROFESSIONAL MEETING
»THE LIFE AND WORK OF NIKOLA TESLA«
(JUNE 28 – 29, 2006)

AKADEMIJA TEHNIČKIH ZNANOSTI HRVATSKE
CROATIAN ACADEMY OF ENGINEERING
www.hatz.hr/TESLA

Harold K. Forsen, Ph.D.
Foreign Secretary – Retired
National Academy of Engineering, USA
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Nikola Tesla: scientist, engineer, inventor[1]

On this 150th anniversary of the birth of Nikola Tesla it is most appropriate that we honor him and in doing this we thank the Croatian Academy of Engineering and their President Zlatko Kniewald for planning and organizing this symposium.

Tesla was born of Serbian parents in the small town of Smiljan, Croatia. He was educated and worked for a while in Europe but this part of his story begins with his move to the United States in 1884 at the young age of 28. To put into perspective the early life of this brilliant contributor to our modern way of life, we should consider where the technical world stood at the time – in this case electricity.

The wide scale use of electricity has been considered the single most important engineering benefit to our society in the 20th century and Nikola Tesla's inventions can be argued as the fundamental technical achievement which made this possible. During the middle to late 19th century the world was just beginning to understand the field of electricity and its potential uses even though it was not clear exactly what electric currents were. Electronic carriers in metals, or electrons, had yet to be discovered but the drivers, electric potentials or volts, were understood. It was also known that electric currents in conductors produced magnetic fields. Magnetic fields in turn produced forces on these current carrying conduc-

[1] Reprinted from *Proceedings: International Scientific and Professional Meeting "The Life and Work of Nikola Tesla"*, June 28 – 29, 2006, Zagreb, Croatia

tors and all electric motors work because of the interaction of magnetic forces. Similarly, generators rotated by power sources such as steam, produced currents, but the currents within the rotating coils alternated in a sinusoidal manner – reversing direction over a cycle or produced an alternating current (AC). This AC was converted to direct current (DC) through segmented commutators. These commutators have electrical connections to the rotating coils and current flows through them by brush contacts which are fixed within the generator or motor. Their use produced undesirable arcs and sparks. City and home lighting was carried out by gas lamps. These were being converted to electric arc lamps and eventually to incandescent lamps as electrical distribution was installed. Tesla had worked on all of these things while in Europe and had brilliantly devised a way to use directly the alternating current produced by generators to drive motors and thus eliminate the commutators. That is, he invented an AC motor and methods to better use this form of electricity.

While this may seem like a small breakthrough, it was really a very fundamental one because motors are what drive industry. Further, AC electricity has much greater flexibility than does DC. Electricity from a DC source has to be delivered to the user at the voltage specifically required for the equipment and this means that the losses during transmission can be very large – growing as the square of the current. The only way to overcome this is to use large copper conductors or have the power source close to the user, both of which are expensive and impracticable. AC can use a transformer to increase the voltage at the source, reducing the current, then step the voltage back down at the user to deliver the same power. Thus transmission losses are reduced and the power can be carried many miles, not the one or two miles typical of a DC system.

Now to get back to our Nikola Tesla story. While Tesla was still in Europe he had worked for the European Edison company and after his arrival in New York, it was natural for him to seek out Thomas Edison to apply for a position in his company and Tesla was hired into the Edison Machine Works. The parent Edison company was rapidly expanding its operation in DC. They were building local generating stations, wiring the city and selling its now mass produced incandescent lamps. Edison's company was heavily financed by the great business tycoon, J. Pierpont Morgan, a person of immense wealth and power and one who would ultimately drive Tesla to despair.

During the course of his employment, Tesla would attempt to interest Edison in his AC system but could not. Edison, a fierce business competitor, was totally disinterested in anything that might slow up the expansion of his DC installations. Meanwhile Tesla undertook several assignments to improve and repair the company's hardware – motors, generators and electric distribution. In this effort he proved to be an extremely hard working and exceedingly bright employee. This attracted Edison's attention and allowed Tesla to gain his confidence but even this was insufficient to permit any real discussion of his inventions. However, Tesla continued the conceptual development of his ideas, both for DC and AC, and ultimately filed patents on several of them – including an improved arc light. While there may have been other reasons Edison would not discuss AC with Tesla, a strong one was that his competitors, Westinghouse and Thompson-Houston among others, were selling DC systems, but were also working on AC developments. Edison was under extreme financial pressure to fund his expansion of his systems and stay ahead of the competition.

Tesla understood early that while Edison was a great inventor, he was also mostly involved in developing the ideas made by himself and his people. His real talent was in implementing and commercializing their new technologies. Further, Edison had little formal education and was not skilled in the theoretical aspects of electricity so that discussions without drawings and hardware were not easy. Since Tesla carried essentially all of what he had developed in his head, there was little common ground in which to communicate. In frustration, including a difference over a possible unpaid bonus for improvements in Edison's direct current systems, Tesla left the Edison company in early 1885 after less than a year.

Because of his excellent work with Edison, Tesla was approached by a few investors to start a company to compete in this new era of electrification and the Tesla Electric Light & Manufacturing Co. was formed. After about a year of work, a complete DC arc lighting installation was made in a small town where one of his partners lived. Tesla had anticipated that the new company would support his AC system development but such was not the case. He ended up being removed from the company with no more to show for his efforts than an engraved stock certificate of dubious value – more disappointment and frustration. To make ends meet in a period of desperation, he took on odd jobs and ironically worked as a ditch digger installing Edison's power lines.

Happily, within a year his luck began to change. Through his foreman to whom he had described his ideas, he was introduced to another group of people with financial connections and an interest in using AC power. In April of 1887, the Tesla Electric Company was established with a laboratory in New York. Tesla contributed all the rights to his patents but only owned four ninths, or less than half, of the company.

During the next months, Tesla developed images his encyclopedic mind had stored in detail into real hardware. Within a short period he constructed a two phase motor, making improvements over an earlier model he had put together while still in Europe. He took the motor to a colleague at Cornell for testing and in October 1887 he filed for patents covering the system. The records indicate that he previously had been granted seven patents. The new patents, which were quickly issued, included three for an electromagnetic motor, two covering electric transmission of power and two covering methods for the distribution of AC electricity.

Within the following year Tesla had developed and filed additional patents on single, two and three phase systems. These included the generators, motors, transformers using three and four wire, three phase and their associated controllers. In May 1888 he presented a paper to the American Institute of Electrical Engineers (AIEE) on only the motor elements of his research. It was a shocking revelation to many that by using multiple phases, the use of AC could be so versatile. Professor Elihu Thomson was in the audience and apparently challenged Tesla that his own work had preceded Tesla's but as Tesla pointed out, Thomson's motor still had commutators. Tesla's discoveries, and his patents, accelerated his launch to fame but not to fortune. Unfortunately, Tesla was never able to fully understand the difference between great ideas and the difficult process of getting them developed and to commercialization. As it turned out, Tesla was more interested in concepts and humanitarian deeds than profits.

As mentioned earlier, Westinghouse had been dabbling in AC and had been working with a single phase system (motor with commutator, transformer and transmission system) licensed from Lucien Gaulard and George Gibbs. They also had licensed a generator developed by Werner von Siemens of Germany. On the other hand, after hearing what Tesla was now doing with multiple phases, his work could not be overlooked. George Westinghouse met with Nikola Tesla and his associates and immediately tried to bring Tesla and his inventions into Westinghouse. An offer of cash for the patents and additional royalties of $2.50 per watt sold were acceptable to Tesla. He also agreed to join Westinghouse for a time in Pittsburgh to oversee the development of the system and, in particular, his motors.

Once again Tesla was to become discouraged. The Westinghouse engineers were stuck on a single phase AC frequency of 133 cycles per second (or Hertz – Hz) based on work they were doing with their Gaulard-Gibbs system, Siemen's generator and power plants they had already sold. Tesla's system and motors had been designed for 60 cycles. Considerable friction arose in trying to solve the conflicting problems relating to costs, existing hardware and ability to manufacture. Here again, Tesla decided to leave Pittsburg and moved back to a new laboratory in New York

In the early years of major competition for the electrification of the country, many small companies failed and considerable consolidation took place. In the final analysis, only the General Electric Co, with J P Morgan's financial help, and the Westinghouse Electric Co. survived. General Electric was promoting and selling DC systems and Westinghouse was developing and selling both kinds of systems. Elihu Thomson, with his partner Edwin Houston, were to survive for some time, also marketing both systems. Thomson-Huston eventually would become part of General Electric. As a result of this polarization of approaches, the so called "war of the currents" began. Edison was fully convinced that AC was wrong and that it was dangerous and should not be used in homes. He went so far as to support the killing of stray animals by electrocution with AC to make his point.

The large amount of capital necessary for expansion of electric installations while the country was facing a depression, resulted in Westinghouse's financial backers demanded a reduction in the costly development still being invested in Tesla's system. As a result, the work was stopped. Further, they objected to the excessive royalties that would have to be paid to Tesla in the event his system was commercialized. George Westinghouse, trying to stand by his bargain but with control out of his hands, had to inform Tesla. Tesla was obviously discouraged but made an agreement that if Westinghouse would continue the development of his inventions, he would give up the royalty element of their agreement. This done, the work eventually resumed and multiphase 60 cycle motors, generators and the accompanying systems were developed. Tesla, as a result, saw his dream fulfilled, but he had given up literally millions of dollars of future royalties. Again, his humanitarian goals were his first priority.

Tesla continued working on new ideas in his laboratory. He could produce higher frequencies by adding poles to his generators and rotating them faster, but the limit seemed to be about 10,000 Hz. He had designed an oscillating system driven by steam or compressed air that could move a coil very rapidly through a magnetic field to produce high frequencies, but this too was limited because of the mechanical nature of the apparatus. Tesla clearly understood the earlier work of Michael Faraday with oscillators and the frequency limits of iron core transformers, so that he began to work with air core transformers. By using capacitors as drivers, with the self inductance of the transformer, he could generate resonant, very high frequencies and voltages in the transformer secondary. Repeatable discharges from these resonant transformers were estimated to be over 100,000 volts and 100,000 Hz. Because of the transformer effect, these very high voltages had correspondingly very low currents. Tesla also found that very high frequency currents traveled over the surface of the skin and thus caused no real harm to a person when holding on to a terminal of the discharge. As a result, his body could act as the carrier of this form of electricity and he was able to create discharges in evacuated glass bulbs held in his hands. Similarly, isolated glass bulbs throughout the lab could be illuminated by the resulting fields. He could also detect a warming effect on his body with discharges of the appropriate frequency. Patents were filed on the apparatus and applications for these devices. Today this process is known as “Diathermy.”

While Tesla would forever be proud of his Croatian birth and his Serbian parentage, in 1891 he became a citizen of the United States.

Tesla’s new and exciting discoveries on AC systems resulted in his being asked to give lectures in 1892 at the Institute of Electrical Engineers and, subsequently, the Royal Society in London, and the Physical Society and International Society of Engineers in Paris. In his lectures Tesla described the broad series of inventions and developments he had made and the talks were well received by his audiences. In London, Tesla presented Lord Kelvin with one of his “Tesla Coils” – a useful and clever device which was to become famous for probably centuries to come. One interesting outcome of the London presentation was that Lord Rayleigh advised Tesla that, with his great talent, he should concentrate his research on one great idea. As we know, this would be impossible for Tesla.

On returning to his laboratory in New York, he refocused his efforts on resonances and produced multiple wavelength electromagnetic (EM) signals that he could pick up at various places around town. To do this he had to ground one side of his secondary transmitter to the piped-in water supply. This grounding issue was to become very important in the future as it became fundamental in wave polarization and propagation. Tesla’s research into the ability of different frequencies, or wavelengths, to propagate along the earth’s surface or in the air, set him far apart from other researchers of the time.

Tesla's work on high frequency, resonance produced radiation should not to be confused with the tests of Heinrich Hertz. In 1888 Professor Hertz had sought to show that EM waves traveled at the speed of light and behaved like light waves in order to further establish the viability of the mathematical equations developed by James Maxwell. Hertz's apparatus was simply two oppositely charged condensers linearly connected through rods to a spark gap that discharged when the condenser voltages were sufficiently high. This produced a propagating wave that could be detected by a similar apparatus nearby. However, there was no real concept of controlling the frequency. The use of EM waves by Hertz was thought by him at the time to be of "no use whatsoever." However, Guglielmo Marconi, an Italian, on reading about the experiment, visited Hertz and his apparatus. Initially, using these ideas, Marconi was to go on and eventually develop the concept and hardware for wireless telegraphy.

The development and deployment of various AC power systems continued at a rapid pace. In Europe, systems were being implemented in the UK by Sebastian Ziani de Ferranti and by 1891 in Germany; power from a hydroelectric plant at Lauffen had been carried over a hundred miles away to Frankfurt via a 30,000 volt three phase system. This was designed and constructed by Swiss and German firms represented by inventors Charles Brown and Michael von Dolivo-Dobrowlsky, respectively. Brown subsequently published articles acknowledging that the systems used in the Lauffen-Frankfurt project were indeed covered by patents issued to Tesla. Over time, Westinghouse would sue various patent infringers and in some cases would win, but heated arguments over creative priority would plague Tesla for the rest of his life and greatly confuse some of the written history. Only rarely would significant royalties for the commercial licensing of Tesla's patents be paid to Westinghouse, and even more rarely to Tesla.

In 1892 the US planned to celebrate the 400th anniversary of Christopher Columbus' discover of America. A major lighting exposition was planned for Chicago, the Columbian Exposition. Westinghouse won the contract to provide the power and lighting for the exhibition but George Westinghouse himself had to be convinced by his staff that the benefits that Tesla's system offered made it the one that should be used. General Electric, for competitive reasons, decided it would not issue a license to Westinghouse to produce Edison's incandescent lamps for use at the exhibit. Consequently Westinghouse had to manufacture hundreds of thousands of less efficient, "different" lamps.

The exhibit opened with much fanfare in 1893 with a most impressive display of lights. There were demonstrations by several electric companies from the US and Europe and many of these devices and systems could be tied back to inventions made by Tesla. Tesla was given his own space to demonstrate his various inventions including motors, generators, lighting tubes, a display of his rotating magnetic field and, of course, his high frequency, high voltage system. Using this, he permitted discharges from his body to illuminate lamps held in space – a most spectacular show. A large monument was erected at the site by Westinghouse which advertised that the "Tesla Polyphase System" was being used to produced the exhibitions power and distribute it.

At about this time the harnessing of the energy from the great water falls at Niagara, New York was being revisited and General Electric and Westinghouse were the main competitors for the installation – AC versus DC and Tesla versus Edison. Important personalities, such as Lord Kelvin took sides on these two options. Tesla as a boy had envisioned the harnessing of this great energy source and here it was about to happen. Westinghouse ultimately won the contract for the power plant which was to produce two phase AC electricity. General Electric, having licensed the Tesla patents from Westinghouse, was awarded the three phase AC conversion and transmission lines to carry power some 22 miles to Buffalo and eventually, New York City. The initial installation was over 11,000,000 watts and later expanded to more than three times this – all using the Tesla patented multiphase systems at 60 cycles. It is not known how much General Electric ultimately paid for their license and royalties for the multiphase Tesla system but Tesla never received a cent.

By this time General Electric had acquired the services of Charles Steinmetz through a corporate acquisition. Steinmetz was an outstanding mathematician and electrical engineer who would complement with theory, the empirical approaches of Edison. The General Electric Co. had by this time essentially switched over to Tesla's multiphase AC. Steinmetz was to contribute significantly to the understanding of this part of Tesla's work and do significant original work of his own. However, he never acknowledges Tesla's seminal accomplishments in any of his writings.

In 1895 Tesla's New York laboratory was totally consumed by fire which started in the floors below his. Destroyed in the fire were his notes, records, most of the equipment that had been constructed or purchased over the past several years and what remained of the Tesla Electric Co. This was to be a terrible loss since the lab was uninsured and Tesla still owed Westinghouse for much of the equipment. Prior to the fire, Tesla had been working towards an EM signal transmission demonstration from his laboratory to a distant receiver, thus proving his technique of tuned wireless communications.

Complicating all of Tesla's money problems was the fact that the country had been in the throws of financial turmoil as investors demanded gold to back their paper money. Enter J P Morgan again, or at least one of his people, with offers of support for Tesla and his work. While no formal agreement appears to have been reached, some funds were furnished and another new laboratory was set up in New York. After about a year, Tesla was in operation again and he resumed transmission testing. At the time, the principal application was to replace the wired telegraphic data transmission with wireless telegraphy. That is, the making and breaking of the signal would produce the dots and dashes of Morse code. Tesla had been issued patents on the tuned wireless transmission process in 1897.

Through the course of his research during the past several years, Tesla had used his resonant air core transformer apparatus to explore many things. Among them was the use of evacuated glass bulbs that contained electrodes and, at times, various gases –similar to that of his friend Sir William Crooks. In this work he discovered that phosphorescent and fluorescent coated tubes produced brilliant light. He could also bend gas filled glass tubes which could be illuminated by excitation to write out names – neon signs. These things were all demonstrated at the Columbus Exposition. One interesting phenomenon that was not demonstrated there was that when using his so called metallic button lamps, where brush discharges occurred, the button would vaporize – depositing the metal on the glass tube walls. Ultimately he would discover that the radiation emitted from similar lamps produced an exposure on photographic paper and that this radiation would penetrate solids, including the human body – x-rays. Because of Tesla's unwillingness to publish or discuss the details of his work before he had fully developed the idea and/or the hardware, it is not clear when his "shadowgraphs" were first produced. However, Wilhelm Roentgen, in Germany, would make a similar discovery in 1895 and in 1901 receive the Nobel Prize for his contributions to the discovery of x-rays.

At the Electric Exposition of 1898 in New York, Tesla demonstrated a robotic boat controlled by multi-channel or frequency EM waves. The boat had multiple small motors or servos that produced its propulsion and steerage and would flash its lights in response to questions. It was remotely controlled by Tesla using a telegraph key. The US was involved with the Spanish-American war at the time and Tesla offered to support the development of a remotely controlled torpedo but he was turned down. Throughout Tesla's life he was against war but continued to work on devices that could be used for defensive purposes. Remote control would become a major use of EM waves.

In 1899 Tesla was made an offer to move to Colorado where he was to receive free electricity to power his experiments. A facility was constructed with space for the installation of a very large oscillator/transformer and a 200 foot tall, adjustable length (tunable) antenna with a dome. Here he also understood the importance of a grounding system and took considerable pain to provide a suitable coupling to the ground. With his transmitter he could generate million volt lightening bolts, ones that would rattle the mountains with their noise. Tesla wanted to measure the electric potential and resonant frequency of the earth and find ways to couple to it with his system – perhaps deriving power. This may be where he began to feel that the energy of the earth could be made available for public use, free energy, and again exhibiting his humanitarian goals. One evening when he and his equipment were ready for a particularly strong test, the switches were thrown and extremely high voltage lightening bolts of several millions volts emanated from his domed tower, producing discharges over a hundred feet long. Before long this power demand destroyed the generator at the local power company and the town went dark – not the result he had hoped for.

Tesla returned to New York, again a bit discouraged and again, essentially out of funds but still hoping someday to return to Colorado to continue his work. On arriving in the city it was made known that Marconi was in town lecturing and seeking funding for his wireless development. The two met. It seems clear that Tesla did not think much of Marconi's untuned Hertz oscillator for producing EM waves. Since only very crude tuning was possible, by varying the length of the rods between the capacitor energy sources. and Tesla saw this as impractical for private communications.

Meanwhile a publisher friend of Tesla's had encouraged him to write an article on some of his wireless research. Tesla worked long on this but ended up writing a very different summary of some of his work and his ideas for the future. The article was published in the "Century" magazine and titled "The Problem of Increasing Human Energy." Some of the sections describe his theory and accomplishments in wireless, together with pictures of the Colorado apparatus, but most of his topics were much more philosophical, conjectural and metaphysical. The controversial article attracted the attention of many – one of whom was J. P. Morgan who saw some commercial opportunities in it. A number of other readers critically challenged the article, undermining Tesla's credibility and fundamental reasoning – similar to what had occurred earlier in the development of multiphase AC. Many published responses were slanderous, unprofessional and personal attacks on Tesla and these were widely distributed by the media. Unfortunately this became part of the story of his life and contributed to his lack of recognition by many contemporary scientists and consequently on recorded history.

In subsequent meetings with Morgan, Tesla sought funding for a transmitter that could carry wireless messages across the Atlantic, claiming his system far superior to Marconi's. Morgan, ever the business man, had extensive holdings in railroads, banks, iron and steel, and General Electric and could see wireless business communications as a future opportunity. On the other hand Morgan knew of Tesla's controversies, his dealings with Westinghouse and otherwise his inability to commercialize his inventions. Finally in early 1901 they agreed to proceed with $150,000 from Morgan and a 51/49 stock split for the new company – the ownership ratio was suggested by Tesla. However, Morgan apparently wanted to be a silent partner which would bring no external support or business credibility to Tesla. The initial facility was to include a 95 foot tall transatlantic transmitter at a site chosen by Tesla. However, in the final agreement submitted by Morgan, and reluctantly signed by Tesla, Morgan would also control *all* of Tesla's lighting patents.

A site was chosen in Long Island, New York named Wardenclyffe but as the design proceeded, the stock market crashed – partially as a result of Morgan and his railroad competitors. This resulted in prices going up, and so did the cost of Tesla's laboratory and its transmitting antenna. On approaching Morgan for additional funds, and trying to sell him on an even larger antenna, Morgan essentially threw Tesla out of his office, claiming he had not completed the original antenna or commercialized the lighting opportunities. This approach and attitude was to continue throughout Tesla's interface with Morgan. He had many turndowns and received no additional funds. Tesla had apparently told Morgan of his idea to use the transmitter to propagate free energy from the earth. Such an idea would be totally contrary to Morgan's thinking as a businessman. In any event, the laboratories were built and work on the antenna begun – a cone shaped structure now rising to over 150 feet with copper sheeting to be added around its spherical top. Tesla was careful to include a deep complex tunnel for the grounding side of his system and it would become evident that he had anticipated using the facility for more than just wireless communication across the Atlantic. As might be expected, the cost of the facility, equipment and staff became more than was affordable even with Tesla contributing some of his own modest financial resources. While some work continued for a year or so at Wardenclyffe, the facility was eventually closed and sold for scrap by a creditor. Tesla had moved earlier to a small office back in New York. In March of 1913, J P Morgan would die but in spite of Tesla's frustration with him, Tesla would maintain over the years that Morgan was a great man.

During all this, Marconi was developing a system, on which he had filed a patent in 1900, to explore wireless telegraphic communications – not telephonic. In 1901 he built stations in the northwestern US and in England to demonstrate its long range capability. Unfortunately, both stations were destroyed in storms before they could be used. However, within a short time he sent up a weather balloon in Newfoundland, Canada, using a dangling wire for an antenna and was able to receive a Morse coded "s" on December 13, 1901 from a transmitter in England some 2100 miles away. The resulting publicity insured Marconi as the wireless creator as recorded in much of history. Guglielmo Marconi would receive the Nobel Prize in 1909 for his contributions to wireless telegraphy. Tesla would sue for patent infringement but his resources to carry this through were minor compared to Marconi's company and he dropped the action.

All was not over, however, as others doubted the authenticity of the Marconi reporting. Many still clung to the idea that all EM waves traveled in a straight line and the earth's curvature would prevent such long distance transmission – certainly Thomas Edison believed this. About the same time, Steinmetz had become president of the AIEE and at an annual dinner, without Tesla but with many of Tesla's adversaries in attendance, they had a fine time congratulating Marconi and degrading Tesla. As indicated earlier, frequently such discussions were to be the norm among many engineers, scientists and historians throughout the first half of the 20^{th} century. A few, less biased writers would attempt to get the record corrected concerning the invention of wireless telegraphy but it would not be easy. Finally a decision by the US Supreme Court in 1943, after Tesla had passed away, would overturn the Marconi U.S. patents as being preempted by the earlier Tesla patents. This part of the legal record was finally set straight if, only in the U.S.

There is much more that could be added to this story but let me conclude here on a positive note. Nikola Tesla was creative throughout his lifetime – having being issued hundreds of patents. Like many truly gifted persons, he had his own quirks and idiosyncrasies but he was a proud gentleman and was loved by his colleagues and friends who truly knew him. Through much discouragement, he was strong, resourceful and able to come back with great ideas through great persistence. He lived in the U.S. to the age of 87 before he died in 1943, still living in New York.

His contributions to our society and our profession are truly great and without his developments and inventions, we would not have realized for many years the comforts we enjoy today. For this, he would be pleased. Gifts to society in a humanitarian and intellectual sense were more important to him than the financial benefits he was unable to enjoy himself -- but certainly were enjoyed by many others. He has been honored in many ways: by awards during his lifetime, medals, honorary degrees, published articles, academy membership, stamps and monetary notes in his name; by his name being used as the international unit of magnetic flux density, the Tesla; by his statues in many major universities and other important places, with new ones added as recently as this year; by the several dedicated museums displaying his works; and, by the gratitude exhibited by his countrymen, his fellow scientists, engineers and inventors. We honor him with this symposium and hope the publication of the proceedings of this conference will help to continue to set the historical record straight – even 150 years later.

The material for this summary was taken from numerous resources found on the Internet and essentially two books: John J. O’Neill, who knew and interviewed Tesla, “Prodigal Genius: the Life of Nikola Tesla” 1944, and the very detailed and scholarly work by Marc J. Seifer, “Wizard: the Life and Times of Nikola Tesla” 1998. Dr. Seifer was also kind enough to review this paper and for this, I am most grateful.

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Tesla Vision Lives on in Ericsson[1]

From the time our first cry announces our arrival into the world, our need to communicate starts to grow. Interacting with our parents and friends, and sharing ideas, we develop our social skills; communication becomes a fundamental part of our lives. We soon want to communicate over longer distances and while on the move.

Mobile communication is now a part of the everyday lives of more than 2 billion people, and it will reach 3 billion during 2007. New ways to enjoy media are constantly emerging, with news, music, gaming, television and other experiences conveniently available any time and any place via fixed and mobile broadband.

Communication is also improving our professional lives, with greater working efficiency, smarter business processes and increased flexibility in blending private and professional life. These are all vital elements of our vision that motivates us as we lead the way into the all-communicating world of the future.

However, two-thirds of the world's population still do not benefit from communication services. Making communication available and affordable for everybody is an equally important dimension of our vision.

Putting appealing, easy-to-use communication services in the hands of billions of users is a great challenge. It requires not only innovation and

[1] Reprinted from *Proceedings of the International Scientific Meeting "The Life and Work of Nikola Tesla"*, June 28 – 29, 2006, Zagreb, Croatia

technology leadership but also a deep understanding of consumer requirements, market conditions and the ability to undertake large-scale assignments. Only a few companies can make this work end-to-end, all the way from one person to another, regardless of which devices and networks they are using.

Ericsson thrives on such technical challenges, but being the prime driver also requires people working together to create new services, new solutions, new ways of communicating for the benefit of all people. At Ericsson we have all of this, and that's one reason why operators choose to partner with us more than with any other supplier. That's also why we can confidently say that we are uniquely positioned to be the prime driver in an all-communicating world.

However, we owe the communication possibilities of today to great visionaries and scientists of the past, because radio, the telegraph and the telephone are closely related. Nikola Tesla (1856-1943), one of the fathers of radio, paved the way for many of the technological developments of modern times.

From vision to technology leadership

Ericsson has a long history of innovation and in pioneering new technologies for more efficient and better quality communication. We invest around 16 percent of our sales into Research & Development each year and we look for positive, long-term contributions to the communities in which we work and the world in which we live.

Bringing faster, more reliable and more cost-efficient networks to the world is what we do best. When operators choose their equipment suppliers they are often selecting a partner for the next 10-15 years. It is important for us to be able to show that we have been in the business a long time.

In fact, we have never left a country or let down our customers. We have lived with them through troublesome times of war, revolution or natural disaster. In addition, our early involvement with, and substantial contributions toward, creating the world's leading technology standards enable us to be first-to-market with many of these solutions.

With nearly one-third of our employees working in R&D and one of the industry's largest mobile-system R&D programs, we are a technology leader.

We hold more than 20,000 patents worldwide and registered as many as 4000 new patents in the past year alone. We are a leading contributor to the standards for GSM and WCDMA technologies, as well as a significant holder of Intellectual Property Rights (IPRs) in many other technologies. While our ability to license IPRs to other vendors generates additional revenues for Ericsson, our deep commitment to developing technology based on open standards is key to our success.

In addition to both mobile and fixed networks, we also develop and license technology platforms, including the chip design and software that are inside many of the world's most advanced GPRS and WCDMA handsets.

With the latest developments such as "turbo 3G" or HSPA, next-generation networks and all-IP technologies, we are at the forefront of technology. But it is not enough to be the leading innovator. It is also important to understand what our customers, and their customers want, in order to succeed in this tough market.

Global vision, global presence

We are able to contribute to an all-communicating world and share the vision of the great thinkers, such as Nikola Tesla, thanks to our global presence in more than 140 countries, and with more local resources than any of our competitors.

Our operations are spread evenly across the globe, with a quarter of our revenue coming from each of our four regions. The founder of the company, Lars-Magnus Ericsson, was an insightful person who understood the importance of expanding abroad. Just five years after establishing the business in Stockholm in 1876, he had already started foreign activities.

Ericsson Nikola Tesla in Croatia

Ericsson Nikola Tesla is based in Zagreb and has Research & Development activities both in Zagreb and Split. Nikola Tesla, the predecessor of the present company, became one of the first Ericsson's licensing partners in 1953 and became an integral part of Ericsson in 1995.

The Croatian company has contributed to Ericsson's technology leadership over the years. It was behind the idea of implementing SIP (session initiation protocol) into the AXE platform. The solution has been since implemented in the networks of about 10 leading global operators.

Ericsson Nikola Tesla has helped establish a national grid computing project in Croatia, concentrating on the goal of developing a large-scale, worldwide middleware system. It has also been cooperating with the EU DataGrid project conducted by the CERN research center in Geneva. Experts from Ericsson Nikola Tesla have globally acknowledged competence, expertise and creativity, supported by their enthusiasm and customer orientation.

The company incorporates the entrepreneurship of Lars-Magnus Ericsson and the innovative spirit of Nikola Tesla. Its name and actions remind the community of two great men who contributed to the foundations of the new communications era.

Conclusion

The spirit and visions of great thinkers such as Nikola Tesla, Guglielmo Marconi[2] and Lars-Magnus Ericsson live on within Ericsson. This powerful combination has brought value to us and benefit to our customers – and we are rightfully proud of that.

[2] Ericsson acquired Marconi's telecom business in January 2006.

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Nikola Tesla's Patents

Essence of Patent Protection shown in the example of Nikola Tesla's Patents

Abstract

Nikola Tesla is indisputably one of the greatest minds of technology and science of all times. He dealt with inventions from his early childhood, having the model and support in the environment in which he lived. After having finished his schooling in Karlovac, Graz and Prague, and while working in the Telegraph Office in Budapest, Tesla created many inventions in the field of turbines and telegraphy. At that period, he didn't protect his inventions by patents. Coming to the USA in 1884, Tesla soon realized advances of the protection of inventions by patents, a mechanism which would enable him to present his enormous scientific and technological potential, to transfer such knowledge to the public, and to "put to life" his capital inventions intended for humanity. Tesla's rich technological and scientific contribution resulted in 112 US patents, and several re-applications in various countries, e.g. in Great Britain and Canada. The course of Tesla's life shows that his first priority was to work for the welfare of humanity and to allow the use of information contained in his patents for further technological development. Tesla knew that his achievements had been used for further development of particular technological fields, not showing intention to prohibit it. The timelessness of his inventions became evident in the course of time. Many new fields of human technology were developed owing to Tesla's ideas.

Development of particular branches of technology based on information contained in Tesla's patents, as well as economic and social usability of the same can be observed. Many people took advantage of his ideas in various ways. It *was proved beyond any doubt that some of his patents were "re-invented". Deficiencies of patent protection system of that time made possible the infringement of Tesla's patent right in the Marconi case, who "re-invented" a radio. Tesla's life and his achievements are the best example of the path starting with the idea and vision and leading over an invention to a patent. The chronology of his patents demonstrates all the advantages of the patent protection, and possible infringements of the inventor's right conferred by a patent.*

Introduction

When dealing with any of the subjects related to Nikola Tesla, one could hardly separate his life from his inventive work. His life was completely dedicated to his constant interest in primarily the field of electricity, and other related fields. To Tesla, disciplined, as he was, ingenious, dedicated and exceptionally educated, the work and inventions represented the essence itself of the life. His mission was to "take" as many laws of the nature as possible from the nature and give them to the humanity.

The relationship between Tesla's inventive work and patenting of inventions was unbreakable most of the time in his life. Not taking into account his inventive contribution before his departure to the USA, and periods in which he didn't have his own laboratory, where he could realize technically his inventions, the majority of his inventions were protected by patents.

Other Tesla's inventions have been partly saved in the notes taken at his lectures, articles published in various scientific and popular journals and famous "birthday parties addressing" to the public, in which he presented plans for his future research and his visions of the development of particular technological fields.

According to a fairly strong, but never completely proved indications, it is presumed that a part of Nikola Tesla's inventions has been deposited in the manner that they are not available to the public. However, from his personal correspondence it may be concluded that this inexhaustible genius was working on new inventions covering various fields to the end of his life.

It can be said that information contained in Tesla's patents are the only information that are available in their entirety to the general public, in particular nowadays, when searches of electronic data bases containing patent documents are widely available.

Development of the Patent System

To be able to completely understand the essence of patenting of inventions and the circumstances under which it is carried out, in the example of Tesla's patents, something has to be said about the development of the patent system experiencing its momentum at the time of Tesla's great inventions, and its relation to an extreme spread of industrial revolution in the 19th century.

The first legal regulation on the protection of inventions by privileges or patents is thought to be the Venetian Law of 1474. Pursuant to that Law the Republic of Venice issued a decree by which new and inventive devices, once they had been put into use, had to be communicated to the Republic in order to obtain legal protection.

Prior to that Law, the English Crown issued letters patent providing any person with a monopoly to produce particular goods or provide particular services. The first monopoly was granted for a period of 20 years, by King Henry VI in 1449, for the manufacture of stained glass. Such a monopoly could have been granted in respect of all sorts of common goods, such as salt, but due to its wide abuse it was revoked. England enacted the **Statute of Monopolies in 1623**, under King James I who declared that monopolies would be granted **only for projects of new invention** for a period of 14 years. The main characteristics of the British patent system of that time were high patent fees, allowing only very wealthy persons to apply for a patent. That system was very complicated, and included 7 – 17 Offices, i.e. institutions, if covering Scotland and Ireland. Briefly, for a citizen not possessing sufficient capital it was almost impossible to obtain a patent. A complicated system of protection made dissemination of information contained in patents also almost impossible.

In 1852, the British patent system was subject to significant changes-fees were lowered, and patent application procedures were carried out only before one office, the so-called "Great Seal Patent Office". Patent specifications were officially printed, published and indexed. Although the British patent system has been in continuous operation for a longer period than any other in the world, it adopted the examination of a patent application as to criterion of novelty only in 1902.

The modern French patent system was established pursuant to the **laws of 1791 and 1844.** The patent applicant had to describe the invention in the way that it could be carried out by the person skilled in the art, but there was no guarantee for patent information to be published and made available to the public. Up to 1902, the publicly available information on the content of a patent was limited to the title of the invention and patent class. Patent fees were extremely high.

Germany passed its first Patent Act in 1877. A centralized administration for the grant of a federal patent was set up. Patent applications were examined by the examiners who were experts in their field. In 1923, the monopoly term for patents was extended from 15 to 18 years. The publication of claims and patent specifications enabled dissemination of patent information before patents were granted. The examination of a patent application included examination of the criterion of novelty, inventiveness and possibility of creating higher effectiveness of the invention applied for a patent. Infringements of patent rights were subject to monetary fines and imprisonment sanctions. At that time, the German patent system was close to the American patent system in many ways.

The Hungarian patent system, which formed part of the Austro-Hungarian system, also including the territories of Croatia, Slavonia and Dalmatia, was established by **the Legal Act of 1895.** A monopoly was granted for a period of 15 years by the so-called Povlasnični ured, constituted by permanent and temporary members, judges and technical staff. Information including the whole content of a patent as granted was published in the official gazette – Povlasnički viestnik. The infringement of the patent right was subject to a monetary fine [5].

In 1790, the American Congress passed the Patent Statute, which regulated the patent system in the USA. In 1836, the United States created the first modern patent institution in the world, significantly different from the national patent offices of that time. In the USA, the system of examination of patent applications was established in 1790. It included the examination of the novelty of inventions and compliance of patent applications with the legal regulations. The system of registration of patent applications was established in 1793. The Patent Law of 1836 provided for the establishment of the Patent Office, whose trained and technically qualified employees examined patent applications. The patent fees were not high in comparison with the fees applied in the European countries, even being ten times lower (Austria), enabling a wider circle of citizens to file applications for their inventions to the Patent Office, and to be granted patents. In 1861, the term of a monopoly granted by a patent was extended from 14 to 17 years.

The information on inventions contained in patents were readily available, and disseminated rapidly owing to the publication of annual lists of granted patents, which were after 1832 published in newspapers. In addition, patent applications could be sent to the Office by post, free of charges. The American patent system was based on the presumption that social welfare coincided with the individual welfare of inventors, and as such, stimulated the conclusion of contracts and the trade. According to the US Constitution, the defense of rights of the patent owners was important in fostering industrial and economic development of the USA [8].

A breakthrough in the harmonization of the international patent system was **the signing of the Paris Convention for the Protection of Industrial Property, in 1883.**

According to its original version, patents granted by any country, which is a party to the Convention, shall be available to all the countries parties to the Convention.

This Convention also established the right of priority, enabling an applicant from any country party to the Convention to keep the date of his application as the date of priority, provided that he claims it in an application filed within 12 months from the first application in any country party to the Convention. In 1883, 11 countries signed the Convention. Today, 169 countries are parties to the Convention [7].

The international patent system has experienced further development. The characteristics of the modern patent system are:

- promotion of the protection of intellectual property of inventors,
- promotion of financing the creation of inventions, owing to the monopoly conferred by a patent,
- licensing or assigning of the patent rights of inventors to third parties, subject to an appropriate financial compensation,
- availability of information contained in patent documents to the general public, enabling further development of a specific technical field,
- development of the legal system in terms of the protection of intellectual property rights

Nikola Tesla's Patents

Tesla's dedication to inventions began very early in his life. As a boy, interested in the problems of his environment that he wanted to solve, he came to more or less successful practical solutions. Tesla himself has mentioned in his autobiography some of his first inventions, as well as the fact that he is thankful for his inventive spirit first of all to his mother and the members of her family who were all very inventive people [6]. There is no record that any of them applied for or was granted a monopoly, i.e. a patent for the improvements of various agricultural or the like devices. In the Austro-Hungarian Monarchy early in the 19th century, the procedure of obtaining the rights to a monopoly was complicated and very costly.

At the age of 13, Tesla's attention turned to water turbines, and he himself constructed some of them. A breakthrough in Tesla's life occurred when he was 17, and attended the Real Gymnasium in Gospić, where he, under the stimulating influence of his professor of physics, became interested in electricity. Attending the second year of the Polytechnic School at Graz, he conceived an alternating current motor without brushes or commutator.

He dealt with this area up to 1882, when working at the Central Telegraph Office of the Hungarian Government in Budapest he devised a solution to the principle of rotational magnetic field, created by two or more alternating currents of different phases. According to Tesla's words, after that, ideas came in an uninterrupted stream, and in less than two months he evolved all the types of motors and modifications of the whole system [6]. In 1883, he undertook construction of the first prototype of alternate current induction motor in a mechanical shop in Strasbourg. Another Tesla's invention from that period, a telephone amplifier, was not patented, so information about it could not be found in the patent literature. This invention was soon put into use by the general public and thus became a public good. Tesla has never applied for a patent for this invention. The reason for such a long period between the idea and the solution to a technical problem and its practical realization was Tesla's heavy schedule, lack of understanding of his environment for his solutions to problems, and lack of capital for the realization of such practical solutions.

One may ask why Tesla hasn't patented his inventions.

It is supposed that the reason was the European patent system of that time which was complicated, and included high fees. At that time Tesla lived in Budapest, which was one of the capitals of the Austro-Hungarian dual Monarchy. The first modern patent law for that territory was established in the Legal Act of 1895. We may presume that in Europe, in mid 19th century, the idea of patenting inventions was relatively unavailable even to Tesla, and its effects and advantages were insufficiently clear. Meanwhile, Tesla moved to Paris and took a job in the Continental Edison Company, but there, he couldn't find interest in or financial support for his inventions.

In 1884, Tesla came to America and took a job in Edison's laboratory, where his work was not evaluated in the satisfactory manner.

After foundation of the Tesla Electric Company in 1884, in 1885 (Figure 1.), Tesla began to apply for patents for inventions that he created when working on the improvement of electric lighting.

In 1887, after foundation of the Tesla Electric Company, Tesla eventually had a possibility to develop a system of alternating current, conceived in 1882. This resulted in the number of patent applications filed to the US Patent Office in the period from 1887 onwards (Figure 1.). Soon, he

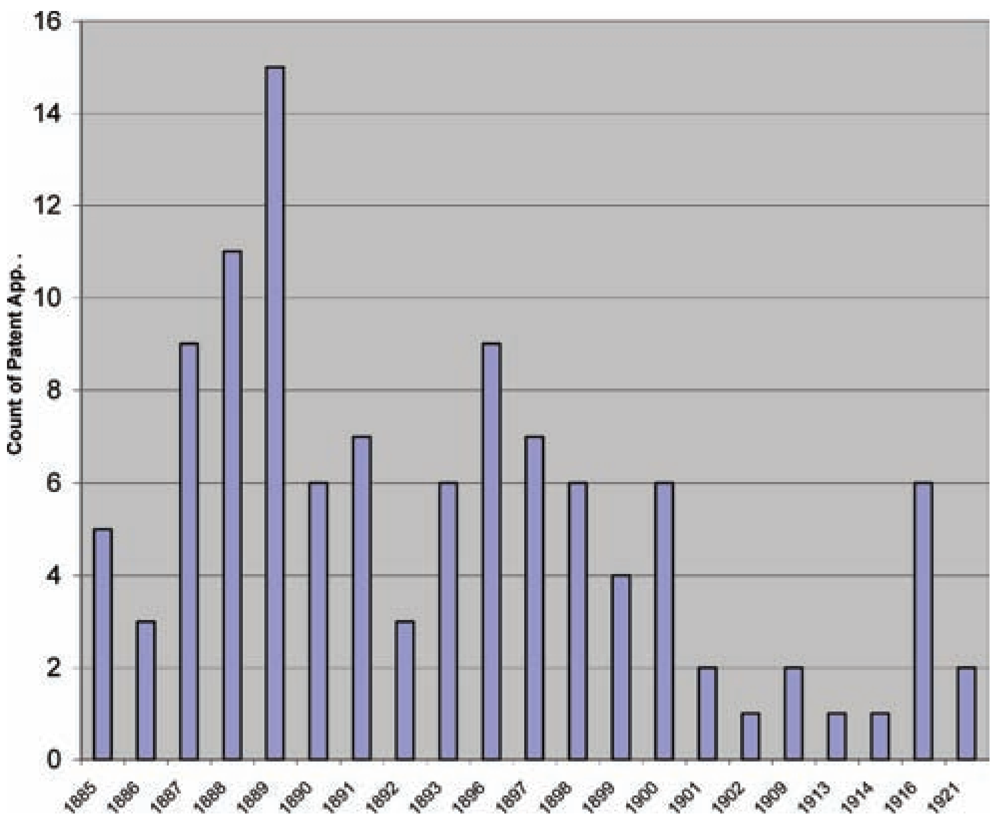

Figure 1. Tesla's Patent Applications in US Patent Office

applied for his first patents related to alternating current. Up to 1891, he applied for 40 patents, and all of them were granted.

He obtained 60 thousand dollars for those 40 patents from the Westinghouse Company. According to the Company's records, under the contract, Tesla should receive 2,50 dollars per each horsepower of electricity as sold. Later, Tesla waived that contract, having a promise from G. Westinghouse that his poly phase system would be maid available to the whole world [5].

In 1897, Tesla sold his patent rights and received 216.600 dollars.

The so-called war of the currents began, in which all the means were used – from propaganda to trials for the infringements of the priority rights. Hundreds of electric power producers used Tesla's patents (4), trying to claim that their inventors invented them. In 1900, the judgment delivered in Tesla's favor confirmed its right of priority in the field of alternating currents.

Certain stagnation in the number of patent applications filed during 1892 (Figure 1.), is likely to be due to Tesla's tour of Europe, where he gave numerous successful lectures.

In 1893, after his return to the United States Tesla gave a lecture in which he described in detail the principle of radio-technique. The lecture was published and translated into many languages, being in such a way made available to the public, which was sufficient for Tesla to ensure priority for the discovery of the principle of radio-technique. Although Tesla was the first to demonstrate the communication by radio, and to file the basic applications of such invention to the Patent Office, as well as being granted two patents US 645 576 and US 649 621, that invention was officially attributed to Guglielmo Marconi in 1895.

In 1943, several months after Tesla's death, the US Supreme Court delivered a judgment stating that Nikola Tesla is to be considered the father of the wireless radio transmission. Giving reasons for its decision, the Court stated that Marconi's patent US 763 772 of 1904, did not contain new technical characteristics that would not had been published and registered by Tesla.

Up to early 1960', 11 cases related to patents were brought before the US Supreme Court, out of which two were related to Tesla's patents [5]. The

Supreme Court judged in Tesla's favor in the cases related to patents for poly phase system of alternating currents and radio.

In 1893, Tesla applied for a patent for one of his most important inventions, a coil for electro magnets (although the first patent for a coil named after Tesla's name, US 454622, was applied for in 1891), widely used in various technological fields many years later.

In 1895, his laboratory was caught by fire, in which his whole valuable equipment was destroyed, as well as many results related to his research of wireless transmission of energy, X-rays, and invention related to the production of liquid oxygen.

In that year Tesla didn't apply for any patent, in US Patent Office.

In 1927, Tesla applied for his last patent in US Patent Office.

The time span between the filing of an application to a Patent Office and the patent granting varies from country to country. The American patent system of that time included the system of examination of novelty that have significantly impeded the procedure of examination of patent applications, extending a period up to the patent grant, under the circumstances in which many countries didn't publish information on the content of patents.

In Tesla's case, average time span between the application and the patent granting was a year, or less than a year, except for particular patent applications in relation to which such period was significantly longer. For example, a time span between a patent application and the grant of a patent in relation to the following patents was: US 1 119 732 (7 years), US 555 190 (8 years), US 511 915, US 524 426 (6 years), US 511 559, US 511 560 (5 years), US 487 796, US 1 061 142, US 1 061 206, US 1 329 559 (4 years), US 645 576 and US 649 621 (3 years).

In the period in which Tesla's inventions provoked astonishment and suspiciousness of both the public and professional public, the patent examiners had to perform a difficult assignment. Patent US 613 809 for an invention entitled "Method of operation and device for remote control of a mechanism from a distance" was granted in 1898, only after the examiner-in-chief had visited him in his laboratory to examine the device and the possibility of its functioning [6].

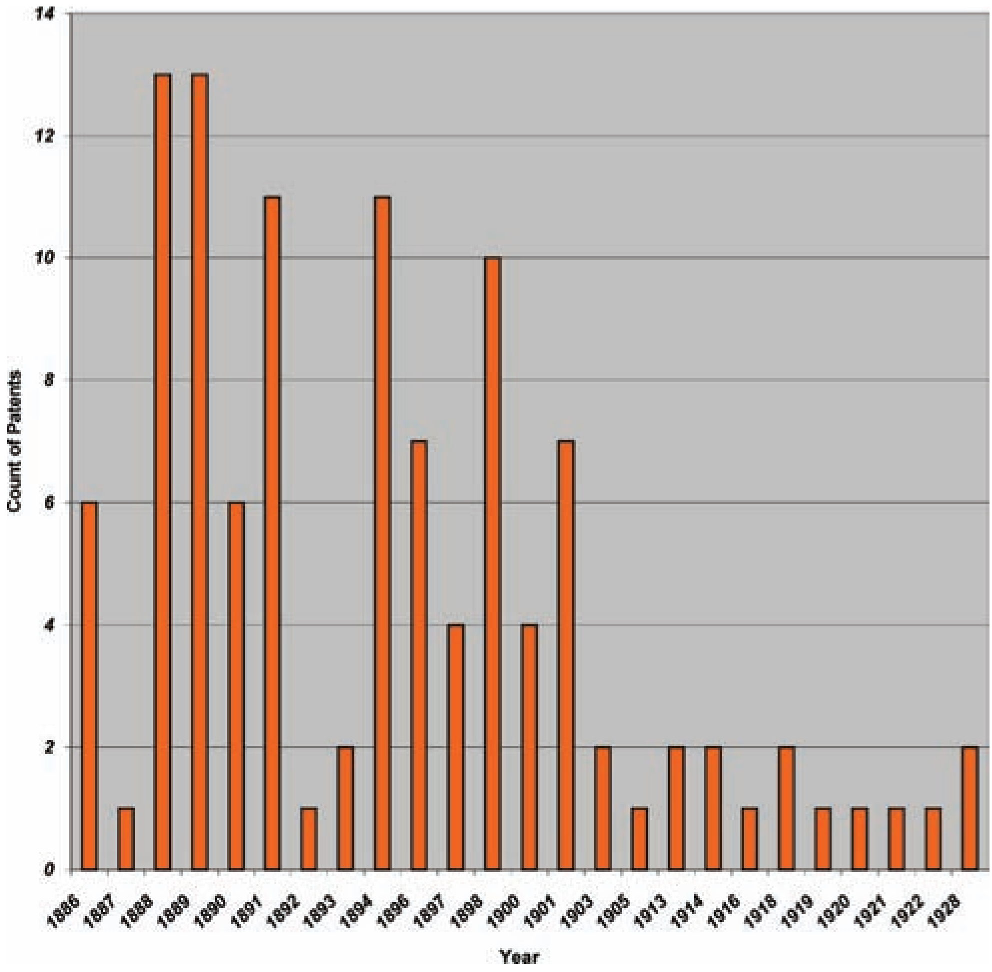

Figure 2. Tesla's US Patents

Nikola Tesla was granted a total amount of 112 US patents for inventions covering various fields of technology. The first US patent was granted to him in 1886 and the last in 1928 (Fig.2.).

Different sources indicate different (total) amount of Tesla's patents.

Territorial principle of the patent protection, according to which a patent shall be granted in each country in which the inventor desire to protect his invention entails the possibility that several patents for the same invention are available in different countries.

Table 1. The number of Tesla's patents in the specified countries

Argentina	1	Italy	11
Australia	3	Japan	1
Austria	4	Mexico	1
Belgium	21	New South Wales	2
Brazil	2	New Zealand	1
Canada	6	Norway	3
Cuba	1	Rhodesia	1
Denmark	3	Russia	4
France	20	Spain	4
Germany	18	Switzerland	4
Great Britain	29	Sweden	4
Hungary	7	Trasvaal	1
India	1	USA	112
		Total	272

Therefore, when establishing the count of Tesla's patents account shall be taken of whether the inventions patented by Tesla (the so-called first patents) or the total amount of patents granted in different countries is to be concerned (Figure 3.).

Ancient patent documents as such from Tesla's time are not available in their entirety, so one cannot establish the total count of his patents, nor can reach facsimiles of each of them. According to the indications available so far, as shown in Table 1, the total amount of available patents granted in 26 different countries/States, including USA is 272 [7].

Tesla's patents can be grouped in several basic groups (Figure 4.). The patents related to alternating current electric machines, chronologically falling within the earliest Tesla's patents (US patents applied for between 1886 and 1893) belong to the largest group. The most important

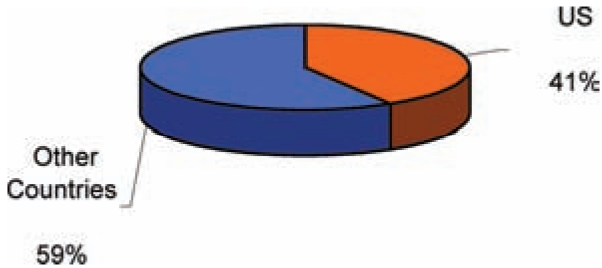

Figure 2. Total number of Tesla's patents

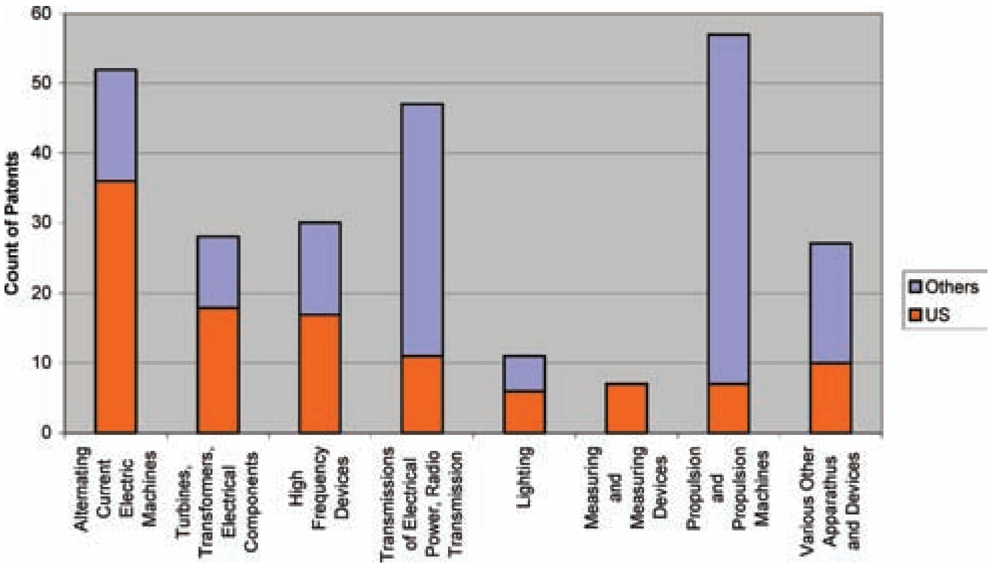

Figure 4. Presentation of Tesla's patents according to technical fields

patents of this group relate to Tesla's poly phase alternating current motors and poly phase systems of supply of such motors, constituting the most famous Tesla's contributions to the electrical engineering. Interesting and less famous patents belonging to this group are those related to a thermo-magnetic or pyro-magnetic motor in which alternating magnetic field has been achieved by alternative heating and cooling of a magnetic body. Almost the largest total count of Tesla's patents – 52[1] patents, or the largest count of US patents – 36 patents belong that group. A group related to (low-voltage) transformers, converters and electrical compo-

[1] The numbers indicate the total number of patents not including unavailable Hungarian and Russian patents

nents (18 US patents, or 28 patents in total) belong to the second, thematically and chronologically related group (US patents from 1885 to 1897). The so-called Tesla's coil belongs to this group. The patents related to lighting (mainly arc lamps) belong to the chronologically subsequent smaller group of patents (6 US patents applied for from 1885 to 1891, or 11 patents in total).

After that, from 1890 to 1898, Tesla applied for a series of patents (17 US patents, 30 in total), related to high-frequency devices. From 1897 to 1902, Tesla applied for patents related to transmission of electric power, and radio transmission.

The inventions belonging to the indicated groups of patents form the most important and the most famous part of Tesla's invention heritage. In addition to that, Tesla applied for less famous and less significant patents covering the fields such as measuring and measuring devices, turbines and propulsion, and various other apparatus and devices (e.g. artificial fountain). It is interesting to note that according to available information the patents covering the field of turbines and propulsion (57 in total) belong to the largest group of Tesla's patents, taking into account their total number, although such count comprises almost exclusively re-applications in the large number of countries (only 7 US patents covering that field). On the other side, according to available information, it seems that Tesla applied for patents in the field of measuring and measuring devices exclusively in the USA, since the re-applications in other countries are not available.

Such consideration of thematically and chronologically related groups of Tesla's patents as shown in Figure 4., indicates the dynamics of his research and inventive work, the subject matters that he addressed in particular periods of time, and the particular strategy that Tesla developed.

Tesla's patents, in addition to their practical application, have inspired generations of scientists and inventors, who inspired by his patents, lectures and thinking, have continued developing particular fields not rarely re-inventing or re-patenting many of his patents. The reason is, to a certain extent, deficiency of the patent system available early in the 20^{th} century, and ingeniousness of Tesla's ideas that have become understandable, "conceivable" and accepted by the professional public.

Searching of the current electronic databases containing patent documents [2,3] may very simply confirm this allegation. Namely, Tesla's patents prevent inventors from obtaining patents even a hundred years after having been granted. Tesla's patents, by the extent of the technical fields covered, and their content being far ahead of their time, form part of the so-called state-of-the-art searched when modern applications are examined as to the criterion of novelty.

This concerns, among others, the following Tesla's US patents cited by patent examiners in the examination of particular modern patent applications: US 613 809 (1 document published in 2005), US 723 188 (3 documents published in 1996 and 2004), US 725 605 (1 document published in 1996), US 1 061 142 (32 documents published from 1972 to 2006), US 1 061 206 (28 documents published from 1972 to 2006), US 454 622 (3 documents published from 1996 to 2002), US 645 576 (4 documents published from 1999 to 2006), US 568 177 (1 document published in 2002).

Among the applicants for the mentioned modern patents are also: Sony Corporation, National Research Development Corp., The United States of America as represented by the Secretary of the Navy, University of Utah, Protein Foods (U.K.) Limited, Hewlett-Packard Development Company, The Boeing Company, Tokyo Electric Power Co. Ltd., Canon Kabushiki Kaisha, Samsung Electronics Co. Ltd.

Tesla didn't want to apply for many possible practical applications of his inventions, and didn't engage to that effect a team of engineers, like his contemporary T.A. Edison.

He would simply continue working, and after explaining one principle, his attention would be drawn to another field.

He didn't have time to apply for a series of inventions related to research tools or methods, e.g. insulating of high-voltage devices by submerging them in oil, a wire constructed of individual film insulated wires bunched or braided together in a uniform pattern of twists and length of lay, the so-called Litz wire, chronometer [1], so they became the public goods. He has also very generously given the inventions protected by patents to the public use, not minding the competition.

In 1956, Gardner H. Dales when addressing the American Institute of Electrical Engineers said that if there ever was a man who created so much and whose praises were sung so little – it was Nikola Tesla. A poly phase system was his invention and his first use of the power of Niagara Falls had set foundations of the power system used today by the USA and all the countries all over the world [1].

Tesla himself said in his autobiography: “Many technical men, very able in their special departments, but dominated by a pedantic spirit and nearsighted, have asserted that excepting the induction motor, I have given the world little of practical use. This is a grievous mistake. A new idea must not be judged by its immediate results. My alternating system of power transmission came at a psychological moment, as a long sought answer to pressing industrial questions, and although considerable resistance had to be overcome and opposing interests reconciled…

These and other inventions of mine, however, were nothing more than steps forward in a certain directions. In evolving them, I simply followed the inborn instinct to improve the present devices without any special thought of our far more imperative necessities”[6].

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Tesla's Works and Works about Tesla in Croatian Libraries, Searchable via Online Catalogue

Abstract

The mankind owes a great deal to scientists. After 2005 being a year dedicated to Albert Einstein, this year is the Year of Nikola Tesla, giving honor to the scientist coming from Croatia. Perhaps these dedications to the great physicists will draw attention of young people to the importance of natural sciences in the overall progress of mankind. Today the technology is changing very quickly, so that the new generations cannot possibly take into account all the roots of its beginnings. Cell-phones, computers, audio and visual appliances, cars and other technical equipment are going through changes from day to day, making it difficult for ordinary people to know all the details of the technology and its changing processes.

But there will always be young scientists willing to look for scientific information in libraries, museums and archives, as well as in the new databases found on Internet. Their willingness for data mining will enable them to widen their scientific horizons.

One such special library is the Central Physical Library, located on the Faculty of Science, University of Zagreb, founded in 1874. The Library has in its possession valuable documents regarding physics, dating from 1662, such as works of Johannes Kepler, Isaac Newton, Ruggero Giuseppe Boscovich, James Watt, Michael Faraday, Alessandro Volta and others. There are also a lot of Nikola Tesla's works, many of them bearing Nikola Tesla's signature, as well as a personal letter from Nikola Tesla. This year makes *an important occasion to present these works to the public in general. The whole Library's collection is searchable via online catalogue, available on the Library's web page: http://www.knjiznica.phy.hr.*

Key words:

150th birthday anniversary of Nikola Tesla, Tesla's works in library, Tesla's works in the Central Library of Physics

1. Introduction

The development of natural science and technology conditions, among other things, the development of other areas of science, among which there is also librarianship, which offers any interested person an insight into scientific achievements. We are experiencing an extraordinary development of technical sciences, especially computer technology, which has caused groundbreaking changes in computer sciences, including librarianism. The libraries have changed the mode of their action and do not await the user in their rooms but have begun to approach the user with their library materials by means of technology, by creating online catalogues. Today, we speak of "virtual libraries", "libraries without walls", e-libraries" etc., which offer their online catalogues or library materials in electronic form. Therefore it may be concluded that the present development in physics and other natural sciences conditions the future development in technology, humanistic and other sciences, which mutually show an interdisciplinarian and international character, and their achievements have no limits in time or space. Today, technology has arrived at astounding inventions, which exactly illustrate the phantasies of Tesla, present from his early childhood. His contemporaries called Tesla a "man from Mars". The great ideal of the Croatian scientist was to serve man, for which reason we are indebted to him, as with his discoveries and inventions, he has changed our way of living.

Physics as a fundamental natural science has provided us with a large number of physical laws; the progress and development of humanity are closely and unseparably tied to science. New ideas turn new pages of several other areas of science, among which technology takes an important place, including its branch electrotechnics with inexhaustible modes of electricity usage. There are several modes for electricity to fulfill its great task: to perform the mechanical work, transfer information, produce the effect of lighting, heat, chemical reaction and to do what man demands of it. Tesla has managed to gain a companion for life in electricity, the invisible effects of which he saw with special senses and with which he has arrived at extraordinary discoveries and inventions. It is difficult to say when man has performed first experiments with electricity, but historical sources ascribe them to Thales of Miletus.[1]

Many years ago, pine forrests extracted resin, which was taken to the bottom of the sea by the flood. Later on, the tide brought hard yellow pebbles to the shore, called amber. When these yellow stones were rubbed with wool, a crackling arose and blueish sparks appeared. Thales called this stone elektron, whereas the power of amber or elektron was called electricity by the Greeks. Many years later, Tesla developed those blueish sparks into lightning, which would light the whole world with its power. In this area, until then unknown and unexplored, Tesla would arrive at great discoveries, today used as a basis for many branches of electrotechnics. Many of his discoveries have been ascribed to other inventors, but with time the injustice shown towards Tesla has partly been corrected. Apart from his large contributions in the area of electrical energy, his contribution in the area of communication processes is also significant, especially related to the wireless transmission.

A citation from a paper presented at the Symposium held in 1976, on the occasion of Tesla's 120 birth anniversary, about the latest achievements in the field of electronics, telecommunications and information transfer: "In the whole world there is one telephone per 12 inhabitants, one wireless set per 5 inhabitants, and one television set per 14 inhabitants."[2] What would we say today, only 30 years after that symposium? Wireless sets have reached such small dimensions, so that their usage and the number of them can not be controlled, not to speak a word about cell phones. Tesla himself once said: "Soon it would be possible to turn on simple and cheap pocket-size devices everywhere, and their users would

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[1] Supek, Ivan (2004) History of Physics. IIIrd edition, Zagreb, Školska knjiga, 2004, pp. 16. (Thales of Miletus in the year 590 B.C. (624 – 547 B.C.) – considered water the original basis of everything, he is called the "father of Greek philosphy", he was the first geometrist and astronomist, mathematician, politician, tradesman. He predicted the sun eclipse of 585 B.C. Historians regard the works of Thales as the beginning of science and philosophy.)

[2] Bosanac, Tomo (1978) Nikola Tesla – the inventor. In: Symposium "Nikola Tesla": on the occasion of celebrating Tesla's 120 birthday anniversary, Zagreb-Smiljan/Gospić, July 7-10th, 1976, Zagreb, Yugoslav Academy of Sciences and Arts, 1978. pp. 11.

be able to hear the news from all over the world, or to receive a message intended to them in person.”[3]

2. Nikola Tesla

On the cover of the *Life* magazine, Nikola Tesla has found his place among the 100 most famous people in the world. The significance of Tesla's inventions applied in practice is huge and his works have made him famous. It is on us to remember them and pay great tribute for everything he has given us. His works, in the area of the technology of high frequency electricity, lighting, radars, remote controlling, fluid mechanics, radiation technology etc. have made the human life more advanced and substantial. The purpose and aim of his idea relates primarily to the humane basis and the idea of bringing the people of the world closer together. Regarding his wireless system, he wrote in 1900:

‘’I have no doubit that it will prove very efficient in enlightening the masses, particularly in still uncivilized countries and less accessible regions, and that it will add materially to general safety, comfort and convenience, and maintenance of peaceful relations’’.

He had no aspirations for personal wealth or gain, all income realised was invested into the establishment of laboratories and the equipment within. His exploratory work was also given priority over his personal life. He had highly developed work habits and spent his leisure taking walks. He had an affection for pidgeons and socialized with writers. It was particularly his strong persistence that lead him to the fulfillment of the goals he set.

Figure 1. Title page of journal "Life"

[3] Cheney, Margaret (2006) Tesla – man out of time. Zagreb, 2006. pp. 251.

Tesla is a person to whom contemporary technology as well as the whole of science owes great tribute, because the basis of his works encompasses present and future implementation. He had the strength of mind and the persistence make the world happier, more substantial and more advanced with his discoveries and inventions. To the injustice, lack of understanding and the refusal to pay him tribute, with which he had to deal, he responded with the richness of new ideas and technical inventions, which he provided to serve the whole world. He lead the present world into the process of the industrial revolution, the world of contemporary communication and computer science. The only thing he asked from the world was to implement his ideas, which can today be measured in practice.

The technological forecasts of Tesla: “It is more than probable that the household's daily newspaper will be printed 'wirelessly' in the home during the night. […] The problem of parking automobiles and furnishing separate roads for commercial and pleasure traffic will be solved. Belted parking towers will arise in our large cities, and the roads will be multiplied through sheer necessity, or finally rendered unnecessary when civilization exchanges wheels for wings.”[4]

In his honour, in 1960, in the 50th session of the *International Electrotechnical Commission,* the unit for magnetic induction is given the name *tesla* (T) ($B=F/Il$) T=N/Am. Apart from the unit of magnetic induction, many objects have been named after Tesla, and his name is also found in many other places, such as:

- Tesla-Transformator
- Tesla currents
- crater on the moon
- asteroid – 2244 Tesla
- on bills (5)
- on post stamps
- the names of magazines (Tesla Messenger)
- names of societies
- names of ships
- names of schools
- names of libraries
- names of institutions
- names of streets and squares

[4] Cheney, Margaret (2006) Tesla – Man out of Time. Planetopija, Zagreb 2006, pp. 324-325.

- The Sixth Division of Lika (in the year 1944)
- Fund for the assignment of scholarships
- medals, etc.

3. Tesla in the online catalogues of libraries

The ideas of Nikola Tesla offered many solutions, yet the number of his drawings and writings is not large, as he was an inventor with a large number of patents and a smaller number of written works. His senses were extraordinarily developed and extremely sensitive, he used to fill his brain with new ideas which would exclude anything else, and arrive at an exact invention with a pure mind, which was shown very often. The inventions, planned and worked out in detail in his ideas, would match the real models and work according to his expectations. Such a work method was represented by a small number of other inventors, it was specific only for Tesla, and it differed even from the pure experimental method in many points. He himself used to point out that he did not want to waste time nor energy on unconcluded ideas. His well-conceived ideas were first realised in his imagination, and only afterwards in practice. His co-workers were introduced to the formed ideas by the presentation of drawings. After he ensured they had solved the presented, he would destroy the drawings and the further work was performed by following the instructions from his head.[5]

It is therefore no wonder, that such a famous inventor, with a large number of patents, is represented by a smaller number of written work in libraries (Table 1.). However, he would become the subject of many works to be created by other scientists and explorers, dealing with his science as well as his person. In Table 1., some online catalogues of European libraries have been examined. Besides the works by Tesla (Tesla, Nikola) and works about Tesla (Tesla), they include the works by Einstein (Einstein, Albert) and the works about Einstein (Einstein). Einstein was a theorist with a larger number of written works, whose natural scientific discovery of the special relativity theory (1905) and the general relativity theory (1915) changed the picture of the universe based on the physical laws of classical mechanics. With the appearance of Einstein's theories, the understanding of space and time was changed radically, and the new

[5] Čuljak, Často. (1983) Uloga Nikole Tesle u razvoju elektrotehnike: magistarski rad. University of Zagreb, Center for Postgraduate Studies Dubrovnik, pp. 66.

physical laws of quantum mechanics offer a new description of the micro-world. After the *World Year of Physics 2005,* the year of Albert Einstein, a theorist who introduced new ideas into physics with meny theotetical works, follows the *Year of Nikola Tesla 2006,* an inventor who provided us with a large number of invents (700).

Table 1. Tesla and Einstein in the European Library Searchable via Online Catalogue

The European Library	Tesla	Tesla, Nikola	Einstein	Einstein, Albert
UK–British Library	118	78	1537	683
PT-National Library of Portugal	0	0	50	36
FR-Bibliotheque nationale de France	65	278	732	2836
DE-Deutsche Bibliotek	571	40	2736	1289
FI-HELKA, Finska	9	0	432	0
IT-SBN OPAC, Italy	24	–	1534	653
NL-General Cat. Koninklijike Bibliotheek	3	0	316	168
CH-Swiss National Library	15	9	1912	1254
SI-National Library of Slovenija	164	138	–	86
HR-Croatian National Library 1990-2003	6	0	14	0
SR-Srbian Union Catalogue	1056	–	252	160
LV-National Library of Litvia	2	2	29	19
DK-Danish National Collections	3	0	243	98

Without any doubt, libraries engage in collecting human knowledge and experience preserved in written form. Characteristic for libraries is a variety of meanings, so they represent locations where library material is archived, collected, procured, arranged, protected, kept and offered for usage. Today, through the introduction of modern technology, libraries have become as open, as to offer users various librarian services. Therefore, when speaking of the development of human science, libraries can not be omitted.

Libraries offer users information they are interested in, and compose online catalogues because of the wish to make the publications as accessible to the user as possible. When browsing through the catalogue of the National and University Library in Zagreb[6], by typing the name Tesla into the browser, the following data is obtained:

- Author – 18 records
- Title – 27 record
- Key Word – 99 records
- Word from the Title – 70 records

The development of online catalogues in Croatia occurred in the following way: The libraries were grouped according to areas of science, and common databases were created. In this way, systems of scientific information were created: Natural Sciences, Technology, Biomedicine and Humanistics, which collected data from small libraries. The data brought together in this way was placed in common bases, which could be searched through[7]. Two terms were entered into the browser (1. Tesla, Nikola; 2. Tesla), in order to separate the works by the author from the works on the author. The search results were:

- Natural Science – 0; 29
- Technology – 30; 30
- Humanistics – 2; 2
- National and University Library – 0; 14;
- University Library in Rijeka – 12; 5
- University Library in Split – 0; 1
- City and University Library in Osijek 1; 2
- Scientific Library in Zadar – 0; 1
- University Library of Pula – 0; 1
- The Croation Academy of Science and Arts – Library – 13; 13
- City Libraries: Bogdan Ogrizović – 5; 7
- Central Library for Physics (SKF) – 7; 11

The data presented in the search through the above mentioned bases do not necessarily offer a true picture of Tesla's work owned by libraries, as

[6] National and University Library (1996-2005) http://www.nsk.hr/DigitalLib2c.aspx?id=114 Accessed on 14th July 2006

[7] The search-engine offering insight into all librarian online catalogues in Croatia (2000-2005) http://preskok.irb.hr/ Accessed on 14th July 2006

it is questionable to which extent the libraries have updated their data in the above mentioned bases.

The promotion of science among scientists, institutions, the younger generations, the inclusion of multimedia presentations into the understanding of science and their relation to other sciences justify the reaching of decisions when announcing years dedicated to great scientists. So may, for example, in the Year of Nikola Tesla 2006, a huge growth in quantity of information on Tesla be noticed by following the net sites of the large search-engine Google Search (enables users to search the Web), during the year (Table 2):

Table 2. Number of records in Google Search – search the Web

Google Search – date of search	22.04.2006.	14.06.2006.	18.09.2006.
Nikola Tesla	1.670.000	1.710.000	2.150.000
Tesla	9.070.000	10.400.000	11.700.000
HR: Nikola Tesla	79.500	118.000	139.000
HR: Tesla	155.000	266.000	370.000
Pictures	9.000	9.200	9.550

4. Tesla's Works in the Central Library of Physics

One of these seven libraries is the Central Library of Physics, which is one of the oldest libraries of that kind in Croatia, holding especially valuable and rare book collection on physics. Here there are complete works of world-known physicists, as well as the inventory book, dating from 1875, in which every acquired book is enlisted, together with instruments, devices, and means of instruction. By regarding and respecting all these riches, and by keeping in mind the function of preserving them for the generations to come, one can easily follow the development of science and education in our regions. The abundance of our scientists, who are recognized and appreciated all over the world, represents the abundance of the environment these scientists come from. All the scientists in their beginnings have been the users of libraries, and later on, they are the builders of the libraries, publishing their own articles and books. By means of modern technology the riches of Central Library of Physics are available via online catalogue at: http://www.knjiznica.phy.hr.

In accordance with its holdings, Central Library of Physics belongs at the same time to the group of faculty libraries, scientific libraries, and special libraries, because it has got predominantly publications on physics. It came into being by moving to the new premises in 1991, and by fusion of three department libraries: the one belonging to the Department of Physics, founded in 1876; the one belonging to the Department of Theoretical Physics, founded in 1920; and the one belonging to the Department of history, philosophy, and the sociology of science, founded in 1961.

The most ancient book in the holdings of the Central Library of Physics is the one Franjo Jambrehović wrote in 1669, and there are also a lot of rare and valuable books on natural sciences as well, which means that the Central Library of Physics compares favourably with many European libraries. In the Library's possession there is also one of the oldest journals on physics, Annalen der Physik, dating from 1799, only nine years after the publishing of the first journal specialized in physics. In this journal Albert Einstein has published his epochal papers in 1905. There is also a collection of complete works by Galileo Galilei, Johannes Kepler, Isaac Newton, D'Andre-Marie Amper, Michael Faraday, James Watt, James Prescott Joule and many other well-known foreign physicists, together with the works of our Croatian physicists Frane Petrić, Ruđer Josip Bošković, Vinko Dvoržak, Stanko Hondl, Oton Kučera, Nikola Tesla, Vladimir Glaser, as well as the works on the history of science written by Ivan Supek, Mladen Paić, Zlatko Janković, Nikola Cindra, and a lot of other authors who have enriched our scientific heritage. All these collections are to be preserved, and at the same time available to the public. This has been accomplished by the online catalogue at the afore-mentioned web address.

The Central Library of Physics counts today (April, 2006) 17,455 books, 580 journal titles (in total 27,584 annual files) – 77 of these with the current subscription, 282 dissertations, 251 master of science theses, 1,378 graduate theses, 2,394 pre-print papers, approximately 200 CD or DVD, together with a lot of manuscripts, pictures, documents, medals… It has to be stressed that the end-users can access the full-text articles from a lot of scientific journals from all over the world.

Search results of the Central Library of Physics online catalogue run as follows:

Author: Tesla, Nikola – 5 records
Tesla – 5 records
Title: Tesla, Nikola – 6 records
Tesla – 7 records
Key word(s): Tesla, Nikola – 11 records
Tesla – 12 records

I. In the Central Library od Physics there is one of Tesla's books with his own signature and dedication (Figure 2.)

Title: Experiments with alternate Currents of very high Frequency and their Application to Methods of Artifical Illumination

Author: Nikola Tesla

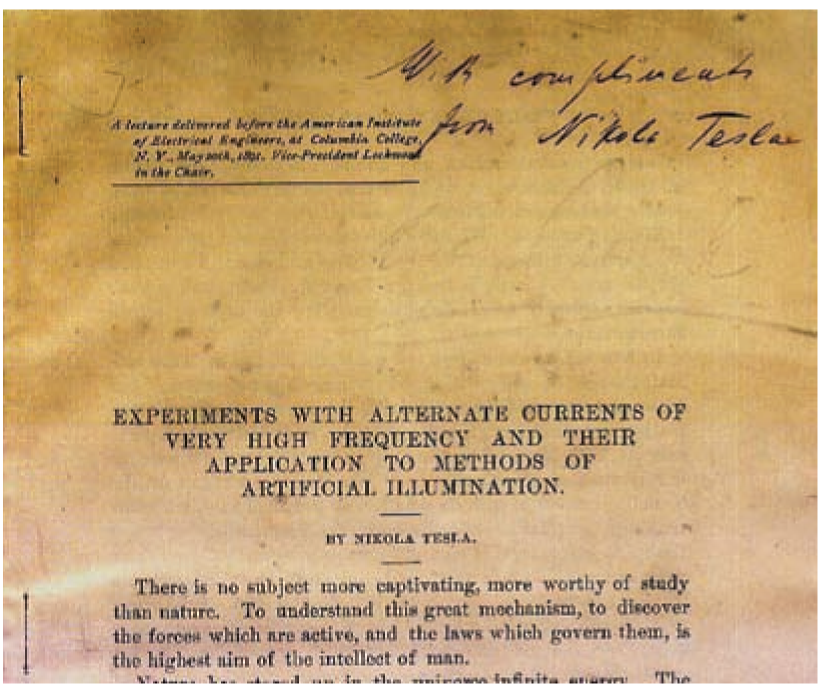
Publisher: New York : American Institute of Electrical Engineers at Columbia College, 1891.

Language: english

Signature: 41.10TESe

Material descripion: 54 str. : ilustr.; 23 cm

Annotation: Book with Tesla's own signature and dedication



With compliments from Nikola Tesla

A lecture delivered before the American Institute of Electrical Engineers, at Columbia College, N. Y., May 20th, 1891. Vice-President Lockwood in the Chair.

EXPERIMENTS WITH ALTERNATE CURRENTS OF VERY HIGH FREQUENCY AND THEIR APPLICATION TO METHODS OF ARTIFICIAL ILLUMINATION.

BY NIKOLA TESLA.

There is no subject more captivating, more worthy of study than nature. To understand this great mechanism, to discover the forces which are active, and the laws which govern them, is the highest aim of the intellect of man.

Figure 2. Book bearing Nikola Tesla's own signature, Central Library of Physics, Faculty of Science, University of Zagreb

II. Nikola Tesla’s personal letters

The letter runs as follows: “To the Radio Belgrade, March 4th, 1941. Lacking in words… I have not informed you properly. It will be fundamental to multiply the number of stations up to twelve. Eight for Croatia… Yours, Nikola Tesla”

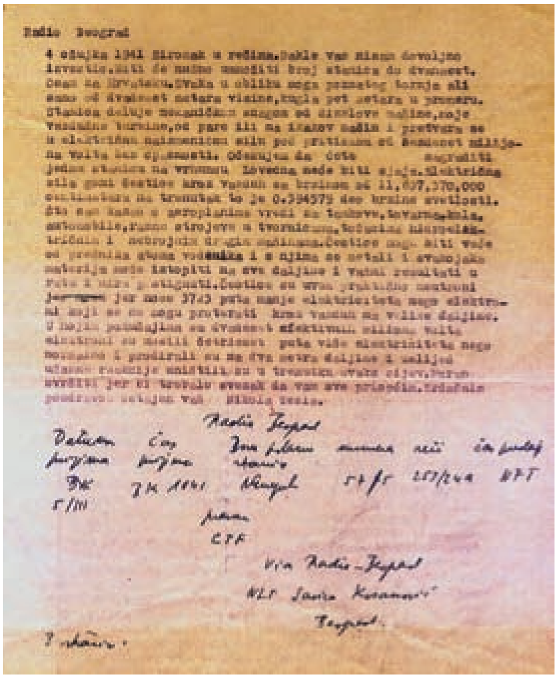


Figure 3. Nikola Tesla's personal letter

III. Revue ’’Naša pošta’’ in the Central Library of Physics (Figure 4.)

A revue dedicated to the postal service and telecommunications, "Naša pošta" of 1932 dedicated its edition (150/2) to the celebration of Nikola Tesla's 75th birthday (1931). The revue had been issued in Belgrade from 1912 (Figure 4). The afore mentioned edition is multi-lingual, and it contains several letters by world scientists, addressed to Tesla for his birthday. A large number of scientists and engineers from all over the world sent Tesla birthday cards and honorary letters. Among them, there were also some Nobel laureats, who payed a tribute to Tesla for helping the advancement of science, as well as their personal scientific career, with respect and gratitude:

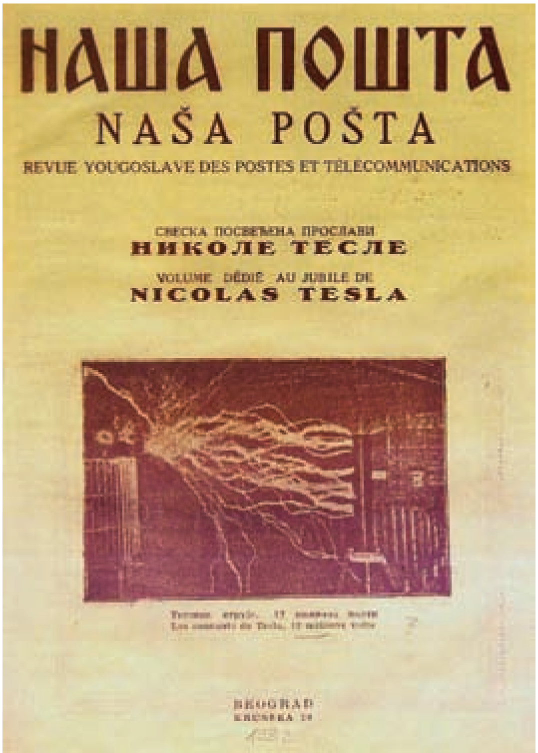


Figure 4. The journal "Naša pošta", published 75 years ago, dedicated to Nikola Tesla

Arthur H. Compton: "To people like Yourself, who have studied the secrets of nature from firsthand and shown the rest of us how its laws may be applied for the solution of our everyday problems, we from the younger generation are so highly indebted, that it can not be repaid at all…" [8]

W. H. Bragg, one of the Nobel prize winners from 1915: "I shall never forget the feeling caused by your experiments, leaving us completely stunned at first, and afterwards deeply thrilled with their beauty and compellingness." [9]

He gave the incentive for the work of many inventors, therefore Li de Forest, the inventor of the triode, wrote him for his 75th birthday: "…be-

[8] Naša pošta: Revue Yougoslave des postes et telecommunications: a number dedicated to Nikola Tesla (1932) Belgrade, pp. 279.

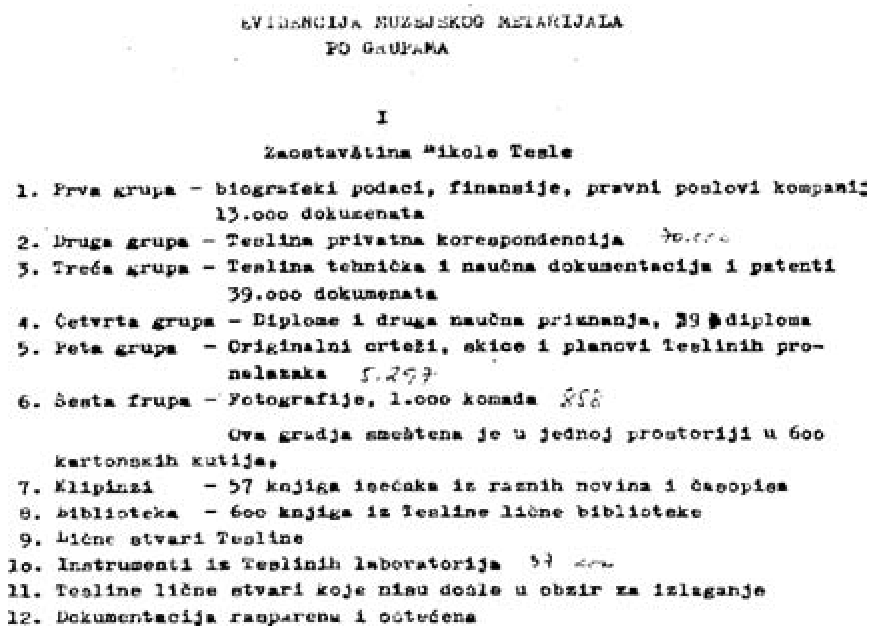
[9] Ibid, pp. 278

cause no one has excited my youthly imagination, stimulated my inventor's ambition or served as an extraordinary example of brilliant success in the area I wanted to enter in the way You did. Your simple statement on one occasion, saying you knew I was capable of continuing, refreshed my courage and gave me new faith in myself, during that time of my painful exhaustion..." [10]

Apart from the honorary letters, biographies and other texts on Tesla's work and life are to be found in the revue.

IV. Document in Central Library of Physics "Files of the museum material sorted in various groups"

Tesla died in 1943. *The Office for the Property of Foreigners* delivered his legacy to Yugoslav authorities in 1952, and the urn containing his ashes in 1957. The document on the legacy of Nikola Tesla (Figure 5.) is to be found in the SKF.



EVIDENCIJA MUZEJSKOG MATERIJALA
PO GRUPAMA

I

Zaostavština Nikole Tesle

1. Prva grupa - biografski podaci, finansije, pravni poslovi kompanij
   13.000 dokumenata
2. Druga grupa - Teslina privatna korespondencija
3. Treća grupa - Teslina tehnička i naučna dokumentacija i patenti
   39.000 dokumenata
4. Četvrta grupa - Diplome i druga naučna priznanja, 39 diploma
5. Peta grupa - Originalni crteži, skice i planovi Teslinih pronalazaka
6. Šesta frupa - Fotografije, 1.000 komada

   Ova gradja smeštena je u jednoj prostoriji u 600 kartonskih kutija.
7. Klipinzi - 57 knjiga isečaka iz raznih novina i časopisa
8. Biblioteka - 600 knjiga iz Tesline lične biblioteke
9. Lične stvari Tesline
10. Instrumenti iz Teslinih laboratorija
11. Tesline lične stvari koje nisu došle u obzir za izlaganje
12. Dokumentacija rasparena i oštećena

Picture 5. "Files of the museum material sorted in various groups", a part of the 9 pages' document, Central Library of Physics

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[10] Ibid, pp. 280.

Has the complete legacy been delivered? At the end of her book, printed in America in 1981 (the translation was issued in Croatia in 2006), Margaret Cheney wrote: “I have discovered, that quite a large object under the name of Tesla is to be found in the third of three libraries of a well-known state security agency, engaging into surveys related to the country's defense. One of those three libraries is open to the public, the second is half open, while the third keeps materials to which only members of the intelligence circles have access.”[11]

5. Conclusion

This scientific and professional meeting about the life and work of Nikola Tesla will bring forward the importance of technical, natural and biomedical sciences, as well as of the social sciences and humanities. The U.S. National Academy has predicted a long time ago that 21st century will be the interdisciplinary century. The institutions archiving and preserving the intellectual goods have the opportunity to show to young people how valuable the scientific creation is. Users are motivated to widen their knowledge by reading books or e-sources, as well as to enrich the libraries by contributing their own intellectual works to them.

The growth of the level of public awareness of the scientific and technological progress and its influence on the development of society meets a great justification in the very announcement of the *Year of Nikola Tesla 2006.* Apart from the fact that a 150th jubilee of his birth is celebrated, a tribute is given to that great man for what he has left us, around 700 invents. His discoveries include: the elecromagnetic coil, the vacuum photographic tube, the wireless energy transmission, radio, remote controlling as the basis of the current science of robotics, cosmic radio waves, the application of the ionosphere in science and many other scientific contributions.

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The Saint of Science and the Martyr of Humanity

Nikola Tesla and the Social Surroundings in which he lived

Abstract

Many generations of people need to be born until a genius appears. Lika has a very long tradition of organized human life. In Lika's Museum the oldest artifacts are 6.000 years old. But the amazing civilization existed there 1.000 years before Christ. That was the tribe Japods (Yapods), a part of the Lyric people, older than the Romans. Japods accustomed to the hard climate in Lika, had a successful economy and even produced wonderful decorated things. A metal Japods cap is for instance very similar today's Lika's national cap.

1. A Historical way to Tesla

In the time of Renaissance Lika was highly developed. In the village Kosinj (Kosin') – about 30 km from the Tesla's Smiljan) the printing house worked only 30 years after Gutenberg's invention of printing machine. There were over 70 mediaeval towns in Lika. One of them was exactly the place of Nikola Tesla's birth house. It was the town that belonged to an old Croatian noble family Bogdanić (Bogdanitch). Even now a hill behind Tesla's house is named Bogdanić hill.

Lika is naturally rich region and it was really rich, but only before the Turk's occupation (1527) which meant a disaster for the old Croatian Catholic Lika's population who mostly escaped to the west or north and the land stayed empty. Some people may have stayed at home, but they were pressed to change their religion.

The Turks leaded with them orthodox people named Wallachs, although they came not only from Wallachia (south Rumania), but from the whole south-east Europe. Some of them had their origin even in Ukraine. In the same time the Serbs was pressed to move from their old country named Raška (Rashka – near Kosovo) to the north, where the Turks formed with that population a pashaluck (similar county).

Many of Serbs escaped outside of the Turk Empire to the Croatian and Hungarian territory within the Austrian Empire. Some of them came even to Vienna, Budapest and Zagreb. The both population were orthodox, but the people on the south and west, including Tesla's region Lika, were mostly not Serbs.

During the time the Turks realized that the Croats were the toughest nut to crack who didn't want to surrender and accept Turk's supremacy even after hundreds of battles of which at least one third they lost. It was clear that their Catholic religion is a reason for that hard resistance. In distinction from the Croats, the Serbs already in 14th Century signed with the Turk's Empire a contract of vassal relation. So the Turks decided to press the Croats to abandon their religion and transit to Orthodox, because Croats mostly refused to accept Islam. Turks made a terrible terror over Catholics and killed many Catholic priests.

At the same time the Serb's Orthodox priests offered to them transit to their religion, so the terror over them would stop. That was the truth and that's why many Catholic believers, mostly Croats, transited to Orthodox. But, that was a trap, while the Orthodox religion was from 1557 – 1766 autocephaly (independent) Serbs church. So every believer in that church was at once pronounced to be a Serb. With the next generations the priests had convinced those people that they are really Serbs.

In 18th Century Orthodox religion was not autocephaly anymore and with that fact it lost their Serb's name and became east ortodox. That name remained even to the first half of 20th Century. But the religion was already under great influence of the hard net of the priests who was the supporter of the Serb's ideas. They even organized from about 1750. , so called Serb's Folk's schools inside of the Austrian Empire and parallel with its system of education.

In the middle of 19^{th} Century in Serbia (still within the Turk's empire) appeared the theory that Serbia should take all the territory in Europe which earlier was under the Turks rule, of course after destruction of both empires (Turks and Austrian). So they needed as many Serbs as possible especially in Croatia and Bosnia. In order to accomplish the task they organized aggressive Serb's propaganda in those regions. The main role in that action had the priests again.

Nikola Tesla was born exactly at the beginning of that Serbs campaign and directly as the son of the priest. So Tesla was pressed by that campaign which had to make influence on the child, although his father didn't seem to be a great Serb's advertiser. Later, Tesla had listened the other side of the story. He abandoned the Orthodox Church, but didn't come to any other. He tried not to declare his nationality, because he was aware that any his declaration makes struggle and hate between Serbs and Croats.

2. Tesla's Friends

In the time of youth he was occupied by his own problems. He had the unwished images and flashes in his had which tortured him. So he couldn't easy make friendships with the other children who hadn't such problems. As an adult, he realized that those phenomena in his head, was actually a gift which enabled him to create new ideas and also develop them into finished inventions.

During the study in Graz and Prague he already had some friends, but not exactly deep friendships. In Graz there was **Kosta Kulišić** (Kulishitch) from Sarajevo and in Prague **František Žurek** (Frantishek Zhurek). Both were impressed with the Tesla's personality and later wrote about him. In that time Tesla already showed the unbelievable memory. Žurek wrote that Tesla could recite the whole book of the lord Byron's verses translated in German language. He was also real champion in billiards giving to the competitors 48 of 100 points advantage and in spite of that he won almost always. He was a wonderful card-player who mostly won the game and earned much money, but at the end he gave back the money to the losers. But when he lost, no one returned the money back to him.

It seems that the first real friendship had Tesla in Budapest. He was fanatically devoted to work, so it was inevitable that his friends had to be people that he worked with. The first such friend was a young Hungarian boy **Antal Szigety**. He helped unselfish Tesla when he suffered of some kind of nerves break down. He had a sort of “super hearing”. He for instant heard the fly which arrived at the table like as the stone fell before him. Szigety helped him to relax his brain by walking, jogging and gymnastics through the Budapest's park. In one of those walking, Tesla had his first revelation and that was rotating magnetic field as the way to use alternating current.

In France Tesla met different people. They were business people, selfish, regardless, greed and cruel. They only seek money. Other ideas didn't interest them. Tesla faced there the first great disappointment, when they avoided give him the promised reward for the hard work in which he saved company from the great loss and shame. But in Strasbourg, in that time under the rule of Germany, he met a different person. It was former mayor **Bousin** (Bouzen), who was aware how precious were Tesla's ideas. He tried to help him by finding rich people who could invest in Tesla's projects. But it was in vain. They also asked only for the profit, which Tesla couldn't promise.

America gave Tesla new possibilities, but the old well known selfishness, regardlessness, greed and cruelty. The story from Paris repeated by Edison who after Tesla 11 months worked 18 hours every day refused to give him promised reward of 50.000 $ pronouncing it to be an “American joke”.

Tesla had many rises and falls in America. He had some brilliant years with splendid popularity. He was a really scientific star. But in course of time the greatest his bad side became more and more visible. He was completely unable to manage with money. He was aware of that problem, but never did anything. Till the end of his life he never realized that the scientist must have his own money. No one other could be generous enough for his expensive experiments. He was always in debt and all the time it became deeper and deeper. Tesla always hoped that his inventions will bring great money and pull him out of the trouble. But that “millions” never came.

In USA, Tesla had a splendid row of famous friend. There was **Samuel Langhorn Clemens** at the top of a list, well known as **Mark Twain**, the “king of laughter”. Not less popular were composers Cechs **Antoněn Dvořak** (Dvorzhack) and **Bedřich** (Bedrzhikh) **Smetana** and a Pole **Jan Ignaz Paderewsky.**

Still the best friend in his social life in that period was journalist and editor **Robert Underwood Johnson**. He made in his home splendid parties with plenty of interesting guests. In organizing of those amazing social events the main person was Robert's wife **Katherine**, very intelligent and emotional woman, who also became Tesla's friend. Here starts the wonderful story of Tesla's relationship with women.

3. Tesla and the Women

Katherine was aware that she loved her husband, but also feels some kind of emotion to Tesla. Tesla didn't want to humiliate his friend by taking his wife and also was hardly consistent in his principle that woman in his life could destroy his scientific ideas. Robert loved his wife, but didn't want to lose the friend. So they kept company through almost 30 years closed into some kind of magician triangle, blocked and frustrated in their emotions.

Other famous women showed also interest for Tesla. Glorious actress **Sarah Bernhard** was his sweet company, but Tesla never went further than the nice chat. The richest “princess” in USA **Anne Morgan** was in secret love with Tesla. She has sent to Tesla a clear signal that she would accept his asking in marriage, but Tesla didn't make that step. She thought that marriage, especially with extremely rich girl, could be a trap in which his brilliant ideas would die.

As in books has been written, Tesla had the closest emotional connection with a young brilliant pianist **Marguerite Merrington**. She fascinated him not only with the brilliant piano playing, but also by absence of any jewelry on her beautiful body. But even then Tesla didn't do anything but a tender chat.

Completely unknown women were sometimes absolutely enchanted with Tesla. **May Cline** wrote him many letters through over 50 years. **Margaret Storm** wrote a book in which she pronounced Tesla to be an alien born on the planet Venera. So she created some kind of religion in which Tesla should be some kind of Mesiah. Although Tesla disagreed with such ideas, that “religion” existed many years.

There is some information that Tesla was sometimes not so resistant to women's beauty. The most serious statement has been written in one of the FBI document that was declassified in the year 1983. There has been written that a special radio before the World War II was a property of the Nikola Tesla's son.

After all there are still many secrets in Tesla's relationship to women. It is obviously only that he was neither gay, nor hater of women.

4. The Victim of Cruelty

Tesla's work and even life were several times attacked with extreme cruelty. First time was during the so called "War of the streams". Edison was decided to prevent Tesla's alternating current by the cruel propaganda campaign that consisted of public killing the animals by that stream with the message: "Don't use such current, it's dangerous". At the end Edison succeeded to kill a human being carrying out the capital punishment with the first electrical chair in prison. But the alternating current still won that "war".

In March 1895, the attack on his work and life was already direct. His laboratory completely burned in the fire conducted with many chained explosions which destroyed everything on the 2nd, 3rd and 4th floor. Tesla later told to Slovenian professor **Milan Vidmar**: "***People are corrupted, Mr. Professor. They demolished my lab by the bomb"***. No one investigated what really happened. On the contrary, the victim was blamed for the disaster. The fire pretended had origin when the pilot burner of the gas ignited mops drenched by oil.

When Tesla was already an old man a taxi hit him very violently while he walked to the park. Tesla never completely recovered from that hit. The victim was self blamed again because pretended in old age he couldn't see well anymore, so he walked "uncarefully". No one investigated which taxi was there, who was the driver, with what velocity Tesla was hit, were there the traces of braking or any other detail. It's known only that short time before that event Tesla announced that he had a mighty defensive weapon called "Death rays". Later even FBI in its document expressed an opinion that Tesla's life is in danger and that he should be guarded, but no one did anything.

Even his death was mysterious. Officially is known that Tesla died 7th January 1943, late in the evening and that his heart stopped by naturally attack. But there is another story that tells that he was already 5th January poisoned by illegal group of mighty persons who wanted to take from him his secret of the "Death rays" and that he lied dead two days in his room.

Although people have done much evil to Tesla, he never said any ugly word about them. He wrote very nice speech to Edison, Morgan and Westinghouse when they died, although they all were unfair to him, but he didn't even mention that facts. Only for Marconi, Tesla had an ugly word (donkey), when he announced himself to be an inventor of radio with Tesla's inventions. The Supreme US Court decided that Tesla was the real inventor of radio after his death. But, neither Nobel's Committee nor Marconi himself did apologize to dead Tesla for that injustice.

Tesla was not selfish and many inventions leaved unpatented, free to use by anyone. Mostly people who used his inventions didn't mention the first inventor. He said by philosophical peace: "***It doesn't disturb me that people used my ideas, but I'm sorry that they had none of their own"***.

So in the end Tesla was a victim of stupid and selfish people in his surroundings, but also of himself and his disability to deal with his finances. In spite of that, he never blamed anyone for his troubles. In that way he deserves the attribute from the title of this tractate:

THE SAINT OF SCIENCE AND THE MARTYR OF HUMANITY

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Innovation Management as a Basis for Successful Development

Abstract

Nikola Tesla's inventions changed the world. Today, when in various markets, including the telecom market, companies continually and aggressively compete for their market share, the ability to produce innovations, which Tesla mastered brilliantly, is the key factor in differentiating the successful and unsuccessful companies. To develop and maintain a company culture favoring innovative approach is the main strategic guideline of any modern company, the Ericsson Group included.

However, an innovator in today's technological and market conditions can no longer act on his own. Handling and supporting innovations should be organized activities, a process with recognized steps practiced by teams of experts and innovators. Such innovation management system has been implemented in Ericsson Nikola Tesla, the company that in its name unites the great inventor Nikola Tesla and the successful entrepreneur Lars Magnus Ericsson who laid the foundations of the Ericsson Corporation. To be successful in innovation management, the company nurtures the winning spirit that motivates project teams to maximize the synergy of the competencies of the company's experts.

An example of a successful innovation by experts of Ericsson Nikola Tesla is the implementation of the Session Initiation Protocol (SIP) in the conventional AXE system. Based on this idea, a prototype was elaborated that won the internal Ericsson contest. The further step was product development, which involved over one hundred company's specialists who worked on the project over one year. The paper gives a survey of the new layer architectures of telecom network with emphasis on SIP that has become major protocol in the world of contemporary telecommunications.

Key words

Innovation management, Nikola Tesla

1. Introduction

Innovation is perceived as a key element of the distinction among companies in present markets. In some particular markets with high dynamics and growth like telecommunication market innovations are even more important for business development.

The high demand for innovation in the modern economy – brought about by shorter technology and product life cycles as well as the sophistication of customers – increased the organizational demand for new ideas. This means two things: first, innovation has to be pushed down to the frontline where the knowledge of the customer is, and where the number of ideas generated is greater. Second, it means that top management has to adopt appropriate innovation strategies to lead the surge of the innovative activity. As a result innovation needs to be systemized as a business process in the way that the organization does business – and hence the need for innovation management. Only organizations that liberate the innovative spirit of their employees, tap the knowledge of their customers and partners, and manage innovation projects as a portfolio are able to reduce time to market with successful products. Examples of such companies are 3M, HP, Microsoft and others.

This is a current situation. The situation 150 years ago when Nikola Tesla was born was different. At the time there was no electrical power in homes and there were not a lot of other commodities that now we are used to have. Tesla's inventions changed the world and today we have the privilege of using his inventions or a number of devices enabled by his inventions.

Tesla is regarded as one of the most important inventors ever. Tesla's patents and theoretical work form the basis of modern alternating current electric power (AC) systems, including the polyphase power distribution systems and the AC motor.

Even though he was a brilliant inventor, Tesla was also an awful businessman. In his history he had not so successful business deals with leading investors of that time. Through this deals, Tesla ensured basic infrastructure for his work. It is a big question if Tesla had a better support for his work, what other achievements he could make.

The paper describes Tesla as an inventor, starting from his early childhood and passing over his unsuccessful business deals. In contrary in the second section, an organized approach toward innovation management, applied in company Ericsson Nikola Tesla is described. One success story resulting from that innovation management system is described in the third part.

2. Nikola Tesla and his inventions

From the earliest childhood Nikola Tesla was showing creativeness [1]. He started with a small waterwheel quite unlike those he had seen in the countryside. From that time some of his experiments were successful, while some were not.

The way how he was seeing his ideas was amazing. Instead of using complex 3 dimensional tools for presentations of complex structures and mechanisms, which are now available as standard tools, he was having a vision of the idea, rotating it in his head.

The story goes that once Tesla abruptly froze in mid-step and mid-sentence. A new concept of AC equipment, long forming in the background of his thoughts, had suddenly crystallized in his mind. His friend wanted to help him to a bench to sit down, but Tesla refused to relax until he had traced a drawing of a new AC motor design in the sand. Six years later Tesla would present the drawing again, this time in an address before the American Institute of Electrical Engineers. He described the process in his head with "*Before I put a sketch on paper, the whole idea is worked out mentally. In my mind I change the construction, make improvements, and even operate the device. Without ever having drawn a sketch I can give the measurements of all parts to workmen, and when completed all these parts will fit, just as certainly as though I had made the actual drawings. It is immaterial to me whether I run my machine in my mind or test it in my shop. The inventions I have conceived in this way have always worked. In thirty years there has not been a single exception. My first electric motor, the vacuum wireless light, my turbine engine and many other devices have all been developed in exactly this way*".

But between having an idea and getting this idea realized there is always a long way. Tesla realized this in a rather hard way. After he moved to America, Edison offered him a job, promising Tesla fifty thousand dollars if Tesla could redesign Edison's breakdown-prone DC generator designs. Tesla agreed and worked to redesign the dynamos, also adding new automatic controls of his own design. The new generator designs were a vast improvement over Edison's originals. Upon completing the job Tesla went to Edison to collect the $50,000 promised for the task. Edison just smiled and said that Tesla didn't understand American humor.

Later, Tesla for a time worked as a laborer on a New York streets in order to keep from starving. After invited lecture in front of the American Institute of Electrical Engineers, Tesla came to the attention of business magnate George Westinghouse. Westinghouse was already familiar with the advantages of AC electricity, and had been one of its' early advocates. He had dreamed of someday being able to provide electricity throughout the country, but the technology to do so reliably had not yet existed. Learning of Tesla's successes, Westinghouse had found what he needed to make that dream a reality.

Westinghouse soon purchased the patents to Tesla's polyphase AC systems, and hired Tesla as a consultant as well. Westinghouse then began to install AC systems across the country, systems which are now in use throughout the entire world. The agreements between Westinghouse and Tesla called for the businessman to pay the inventor a royalty of two dollars and fifty cents – for every horsepower of AC equipment sold. Unfortunately, during a business crisis caused by competition Tesla left the agreement.

It is obvious that Tesla was forced to work with no adequate support for innovation development and deployment which was very disappointing for him. In modern society an organized approach toward innovations is called innovation management.

3. Innovation management

Innovation management can be defined as an organized way to build innovative culture and support innovations creation. It emerged as a discipline in the 1890s with Edison's innovation factory [6]. Edison changed the image of the sole inventor by converting innovation to a process with recognized steps practiced by a team of inventors working together – laying the basic design of the R&D department. These steps are streamlined to the major extent in all industries and include idea generation, concept development, feasibility studies, product development, market testing and launch. Innovation management thus corresponds to the development of new products, processes and services. In cases where the organization does not make or offer products (goods or services), innovation lies in improving the way jobs are done to meet the organization's mission (i.e. process innovation).

Effective innovation management requires a number of processes and tools to be implemented. At the outset it is important that the culture of the organization authorizes employees and encourages them to submit their ideas. Most importantly, the management should adopt the appropriate innovation strategy to lead the innovation process and manage the innovation portfolio. The following summarizes the various objectives that management should aim for under the innovation management stage:

1. Effect a shift in the way the organization sees itself where innovation is recognized as the way of doing business.

2. Decide upon the innovation strategy that best fits the organization's situation, and enable it attain its vision.

3. Create a portfolio of innovation projects to translate competitive strategies and to manage risk across the whole organization.

4. Define criteria for the selection and prioritization of projects within the portfolio to weed out less probable projects as soon as possible.

5. Effect the necessary structural changes to arrange skills throughout the organization in competence centers, to enable the formation of the right team for the purposes of the innovation project.

6. Arrange current and possible future alliances in a portfolio that can be tapped when needed, and define when and how such alliances are to be made (governing conditions).

7. Foster an organizational culture that promotes innovation by allowing employees time to innovate and the implementation of their own ideas for improving job performance.

8. Develop and implement methods that enable tapping into the organization's intellectual capital.

4. Innovation management in Ericsson Nikola Tesla

Company Ericsson Nikola Tesla is very proud to carry in its name the names of great inventor Nikola Tesla and of entrepreneur Lars Magnus Ericsson, the founder of the Ericsson Corporation. In the company strategy the innovation management is a must. The innovation management system is implemented with the following objectives [2]:

- encourage creation of new ideas
- establish cooperation with customers
- establish cooperation with universities
- establish intergroup coordination
- establish cooperation with international standardization bodies
- collect and analyze new ideas
- analyze customer perspectives on ideas
- ensure a short "time to idea"
- support the start of research projects
- support the start of development projects

Since 2000, the company has used the organized approach toward innovation management. The approach includes a variety of activities that encourage and support innovativeness. One of the most important things is a clearly defined process (Figure 1.) which follows up idea from the beginning till the decision upon actions [5]. The process starts with the idea submission. By using the web tool, an employee can easily specify the idea with short summary and more detailed description. If necessary the submitter can upload an additional document to support his/her proposal.

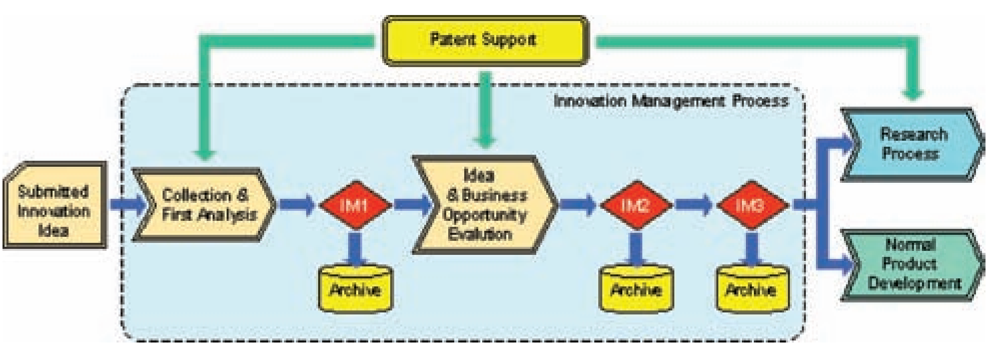

Figure 1. Innovation Management process

Upon the idea submission, the person responsible, i.e. the Innovation Manager, receives the notification. Then he selects, according to the specific area the idea comes from, a person responsible who has previously been registered as a member of the Innovation Management Group. The person responsible analyses idea on his own, also with a help of submitter (additional clarification can be requested) and other persons in the organization with the experience in the area. Periodically, in group meetings all submitted ideas are discussed and suggestions for each idea are given. The suggestions can be to accept the idea as a final solution and to implement it, to evaluate as a business potential, to continue work on it, to reject the idea, to prototype it, to submit as a patent proposal, etc.

The final decision regarding the idea is made in the Innovation Management Steering meeting which is held periodically. The proposals from the Innovation Management Group meetings are either approved or changed.

In all stages, the idea is tested for its patent potential. If some of the ideas should be selected as patent proposal, the final decision is made by Innovation Steering group. Approved patent proposal is sent to the na-

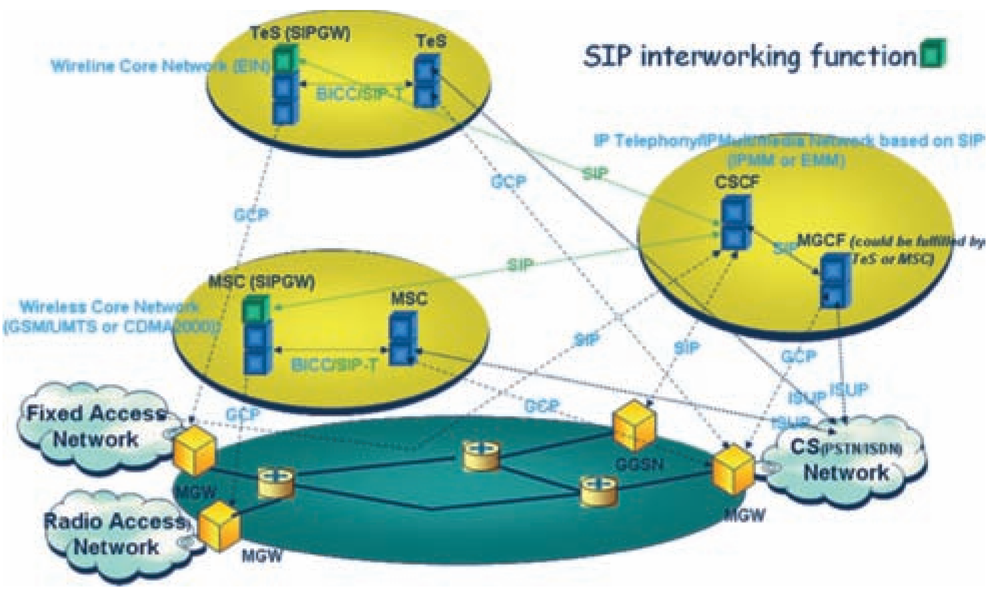

Figure 2. SIP Interworking Function in AXE Server

tional or European patent office. All authors are rewarded with small gifts. If ideas have business potential, or qualify as patent proposal or patent, authors are rewarded with different bonuses.

According to the process, development of the idea can be continued with prototyping activities or an idea can also be an input for product development. The latter is not very frequent but not so long ago we had such a case in the company. Our success story started with the idea of SIP Interworking Function in AXE Server proposed by the employee Vlado Vrlika [3]. SIP Interworking Function in AXE Server offers SIP signaling call control protocol feature in AXE switch, suitable for wireless (MSC, GMSC and TSC nodes) and wireline nodes (Telephony Server). The idea was firstly implemented as a prototype [4] and won the internal Ericsson prototype competition. During the competition the potential of the idea was recognized and later confirmed by customers. The idea was implemented as a product and the development utilized 100 employees for more then 1 year. Today, the solution has been deployed in a number of nodes around the world including very important contracts like Verizon (MCI) and British Telecomm.

5. Conclusion

Innovations are the key factor of distinction between successful and unsuccessful companies. The reason for the organized innovation management is the fact that innovative mind is one half of the success, support for innovations the other. Consequently, the implementation of innovation management system is a must for any high-tech company.

Ericsson Nikola Tesla as a company which in its name carries names of two great men, Nikola Tesla and Lars Magnus Ericsson, makes the effort to the support, encourage and use all innovative potential hidden in the employees.

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Nikola Tesla from the Aspect of Communication

Abstract

The article provides a short history of mobile communication development and it analyzes the technological basis that enabled a widespread implementation of wireless transmission (Global System for Mobile Communications – GSM, Universal Mobile Telecommunication System – UMTS). The report also analyzes the omnipresent and always available communication model realized through the use of various technologies, such as Bluetooth, Wireless Local Area Network – WLAN, Radio Frequency Identification – RFID and network backbone, so that technologically we may use the term communication grid, similar to the vision Tesla had about electrical power grid. Additionally some possible communication models are analyzed that could fulfill the concept of communication grid and to prove essence and validity of Tesla's statement about general wellness that can enable wireless communication system for mankind.

Key words

Nikola Tesla, wireless communication, wireless energy, communication grid

1. Introduction

Nikola Tesla is perceived as a man of vision, especially when it comes to electrical power, because it is in that area that his patents found the fastest and most effective implementation. Furthermore, Nikola Tesla was a man out of time (M. Cheney, 1981). There are a lot of article and newspaper titles that enlighten the role and meaning of Nikola Tesla for modern society published around the world. Here are a couple of them that can express part of his importance: "*The man who invented twentieth century*" [2], "*An outstanding scientist, Nikola Tesla paved the way for modern technology*", "*Nikola Tesla – Man of three centuries*" (J. Glenn, 1994).

To make only a short comment of these statements we can start to think about the industrial revolution and the main benefits derived from it in the twentieth century. We can ask ourselves if these things can be achievable without alternating current (AC) power, can the majority of equipment in our homes and at our work premises do anything without distributed AC power? Many other technological innovations that arose found their roots in Tesla's basic ideas and have started to be a commodity in our daily life. There are still some of Tesla's ideas from the nineteenth century unrealized or not fully understood in the twenty first century. To illustrate this we can take a decision from one United States of America forum regarding electrical energy distribution held in 2002, to have by 2020 a fully applicable system for wireless energy (electrical power) distribution (T.F. Valone, 2003), which was Tesla's experiment a century ago. It is amazing, but fully true, those if we look around ourselves chances are that Tesla is somehow responsible for most of the things that make modern life so modern.

The idea of this article is to point out Nikola Tesla from his achievements and especially visions in the area of communication technology. We also know that his contribution in patents and ideas was significant in the field of communication procedures, especially in wireless transmission. Today most of us are fully aware of and involved in overall wireless communication and the use of wireless communication models and equipment. We are all aware of the fact that Tesla provides to us basic wireless communication principles based on ground technological inventions of H. Hertz and others.

As it stated in the first sentence of this article, Nikola Tesla was a great visionary and it is fascinating to read his statement about wireless systems that he wrote in 1904 (M. Cheney, 1981): "*I have no doubt that it will prove very efficient in enlightening the masses, particularly in still uncivilized countries and less accessible regions, and that it will add materially to general safety, comfort and convenience, and maintenance of peaceful relations*". This is only a small part but it shows the couple of things in connection with Tesla and his vision, and his relation between technology and the wellness of mankind. To analyze this statement we can ask the first question: is this true? With an entire century having passed and with experiences in the broad usage of wireless communication systems we can say this is TOTALLY true. Another question that can be asked is: is it still valid today? Once again the answer is “more than ever”, and it can inspire all of us to enable full execution of this idea and make the world better, with this being the essence of many of Tesla’s idea and his whole life’s dedication.

The company Ericsson Nikola Tesla that carries his name acquired a global recognition as it incorporated in its activities the desire to permanently improve communication for the good of mankind. The joint names of Nikola Tesla and Lars Magnus Ericsson, the founder of the company Ericsson, represent an interesting synergy enabling us to show the present and perhaps the future of communications.

The paper provides a short history of mobile communication development and it analyzes the technological basis that enabled a widespread implementation of wireless transmission (*Global System for Mobile Communications* – GSM, *Universal Mobile Telecommunication System* – UMTS). The paper also analyzes the omnipresent and always available communication model realized through the use of various technologies, such as Bluetooth, *Wireless Local Area Network* – WLAN, *Radio Frequency Identification* – RFID and network backbone. For that combination of technologies we can use the term communication grid, similar to the vision Tesla had about electrical power grid. Additionally, some possible communication models are analyzed that could fulfill the concept of a communication grid and to prove the essence and validity of Tesla’s statement from 1904.

2. History of mobile communications

Nikola Tesla is accepted as first inventor of apparatus for radio signal transmission. As analyzed in introduction chapter he was based his idea on many theoretical experiments from other scientists and his predecessors for idea in physics and communication theory. But first operable apparatus and schema for communication model was done by him. Couple a year’s later one additional entrepreneur and inventor Lars Magnus Ericsson starts to think about “car phone” like basic idea of mobile communication model. It was happen at time about 1910. Legend tells that they would stop their car by an overhead telephone line and hook two long poles into it. A cable connects the other end of the poles with a telephone. And while he turns a dynamo powering the gadget, his wife tries to call the operator so she can chat with her girlfriends while she's out and about.

The real application of radio signal transmission model in communication principles starts at 1921. The next table gives the major years and technological elements that enable wireless communication operable.

Year	Technology and usage model
1921	Personnel of the Detroit Police Department's radio bureau, began experimentation with a band near 2 MHz for vehicular mobile service. On April 7, 1928 the Department commenced regular one-way radio communication with its patron cars. The system established the practicality of land-mobile radio for police work and led to its adoption throughout the country. Channels in this low-frequency band soon became crowded.
1933	The police department in Bayonne, New Jersey initiated regular two-way communications with its patrol cars, a major advance over previous one-way systems. The very high frequency system placed transmitters in patrol cars to enable patrolmen to communicate with headquarters and other cars instead of just receiving calls. Two-way police radio became standard throughout the country following the success of the Bayonne initiative.
1940	New frequencies allocated between 30-40 MHz leads to substantial buildup of police radio systems. A major advance in police radio occurred when the Connecticut State Police began operating a two-way, frequency modulated (FM) system in Hartford. The statewide system developed by Daniel E. Noble of the University of Connecticut and engineers at the Fred M. Line Company greatly reduced static, the main problem of the amplitude modulated (AM) system. FM mobile radio became standard throughout the country following the success of the Connecticut initiative.
1940…	FCC allocates some 40 MHz of spectrum in range between 30 and 500 MHz for a host of mobile services for private individuals, companies, and public agencies..
Late 1940's	Bell System embarked on a program of supplying "public correspondence systems" (communication among a variety of users provided by a common carrier). FCC classified these services as Domestic Public Land Mobile Radio Service (DPLMRS).
1946	First Bell, "urban" DPLMRS inaugurated in St. Louis -- three channels near 150 MHz, manually patched).
1947	A 35 to 44 MHz "highway" system between New York and Boston is inaugurated. It was thought that these frequencies would carry further along highways. This was all too true: due to atmospheric skip, unwanted conversations were carried across country.

Year	Technology and usage model
1956	First manually patched 450 MHz service.
Note	*All of these aforementioned services employed push-to-talk (PTT) operation -- i.e. radio is half duplex which is unfamiliar and awkward for ordinary phone users -- and required operator intervention to place a call. In fact, most of these services were not directly part of the PSTN at all, and involved a radio channel patched into a phone line.*
1964	First automatic 150 MHz service (called MJ). Free channel is automatically assigned. System was full duplex and customers could do their own dialing.
1969	First automatic 450 MHz service (called MK). Extended MJ to new band. Taken together these two services became the (Improved Mobile Telephone Service) -- the standard until the develop of AMPS.
Late 1970's	In spite of the fact that mobile service was, indeed, a scarce luxury, the demand for service was rising rapidly.
1970-77	FCC debates frequency allocation to common carriers. In 1974 it approved the underlying concepts of wireless cellular phone service and allocated for this purpose 666 duplex (two-way) channels in the 800 – 900 MHz frequency range.authorization granted to Illinois Bell in 1978.
1978	Field trials: AMPS (Advanced Mobile Phone Service) trials begin (850 MHz) in Chicago and ARTS (American Radio Telephone Service) in Washington DC.
1979	*World Administrative Radio Conference* sets up research group to define a common international standard. Leads to *Group Speciale Mobile* (GSM) in 1982
1981	NMT (Nordic Mobile Telephone System) enters public service in Sweden. Developed by Ericsson using frequencies in the 450 to 470 band.
1984	Initial deployment of AMPS cellular system.
1991 – 1995	Two funded research projects called Code Division Testbed (CODIT) and Advanced Time Division Multiple Access (ATDMA) were carried out by the major European telecom manufacturers and network operators. The CODIT and ATDMA projects investigated the suitability of wideband Code Division Multiple Access (CDMA) and Time Division Multiple Access (TDMA) based radio access technology for 3G systems. This work was later continued in the FRAMES (Future Radio Wideband Multiple Access System) project and became the basis of the further ETSI UMTS work until decisions were taken in 1998.

Year	Technology and usage model
1993	Responding to a spectacular and unexpected rising demand for wireless services, Congress, in the Omnibus Budget Reconciliation Act of 1993, mandated that the FCC reallocate portions of the electro-magnetic spectrum for "personal communication" and authorized the FCC to employ competitive bidding procedures in awarding licenses for the use of these new spectral resources. The mandate had several objectives, not the least of which was raising revenue to help balance the federal budget. Furthermore, competitive bidding was deemed to be the most effective means to expedite the licensing process and to open up opportunities for beneficial competition.
1995	The UMTS Task Force was established, "The Road to UMTS" report.
1996	The UMTS Forum was established at the inaugural meeting, held in Zurich, Switzerland. Since 1996, the planned "European" WCDMA standard has been known as the Universal Mobile Telecommunications System (UMTS).
1998	Terrestrial air interface proposals (UTRAN, WCDMA(s), CDMA2000(s), EDGE, EP-DECT, TD-SCDMA) were handed into ITU-R.
2000	First commercial GPRS networks launched. Several operators and network vendors claim to be the first.
2001	Ericsson and Vodafone UK claim to have made the world's first WCDMA voice call over commercial network.

This table presents the short overview of major dates and most interesting technology that drives the successful usage of basic idea of mobile communications.

3. Communication technology status today

In order to better understand Tesla's impact on our daily life it is good to make a short snapshot of where we are now in the area of communication technology. We have a very well established wireline network around the globe. We also have a well established wireless network infrastructure and constant growth of subscribers. Today there is wide deployment and use of the second and second and half generation of GSM (2G and 2.5G) networks and services within General Packet Radio Service (GPRS) and Enhanced Data Rates for GSM Evolution (EDGE). The main usage of current wireless network infrastructures is for voice communication, data services and Short Message Service (SMS). At this moment there is active deployment of the third generation of wireless systems

(3G), called also Universal Mobile Telecommunication System (UMTS). Some basic infrastructure and terminals based on Wideband Code Division Multiple Access (WCDMA) coding technology are present. The main benefit of using this new generation of wireless network infrastructure is to provide users with rich services based on multimedia content. The real meaning of this will be better explained later through figures.

One additional technology under broader deployment is the IP Multimedia Subsystem (IMS) that will enable an infrastructure for a controlled service environment based on omnipresent IP technology. The idea is to make available/enable communication goods in a controlled environment to everyone. The main idea in IMS is managed and converged services to be enabled to every subscriber and with unified terminal capabilities. The main essence is to enable users to communicate in a preferable way, using voice or data or both at the same time. In the wireless communication first technology adoption and current research topics is now the fourth generation (4G) of mobile networks and service infrastructure. There are a couple of different standards that enable terminal and user mobility, with the main idea of 4G being to provide the synergy effect of different access technology in order to enable a user to be always connected. If we want to briefly describe the 4G wireless network we can based our description on the motto: “use of any possible access technology to be connected – use services wherever you are”.

To illustrate what is going on and what is expected in the communication technology area, the best indication could be expected network traffic trends. Today’s everyday life in business or a home environment totally depends on communication, and the main aim in developing a communication infrastructure is to have rich communication possibilities. The illustration of trends is presented in Figure 1a for mobile networks and in Figure 1b for fixed networks (Internal Ericsson, 2006).

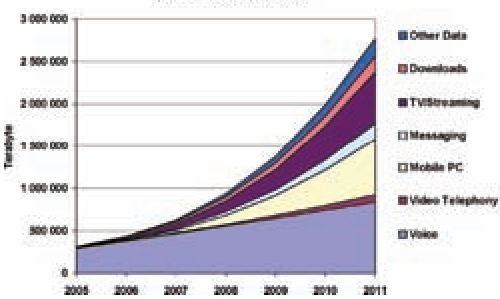

Figure 1a. Mobile network traffic and service trends

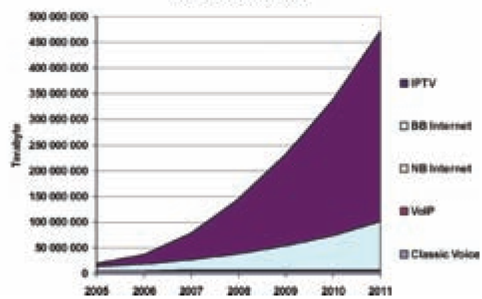

Figure 1b. Fixed network traffic and service trends

On both figures the x-axes shows the years of the analyzed period – starting from 2005 to 2011, while the y-axes shows Terabytes of expected traffic. Two things may be pointed out if we compare these two trends. The first is that in both situations there is a visible expectation of big traffic growth in coming years. Secondly, it is visible that there is a difference in expected service usage. In the fixed networks voice will stay in the same amount but with the expectation of big growth in services based on Internet Protocol (IP) technology, such as Voice over IP (VoIP) or IP based Television (IPTV). Furthermore, big growth is expected in Narrowband (NB) and Broadband (BB) Internet connections.

In the area of mobile networks there is space for more voice services growth, in addition to growth in many data services in connection with mobility (mobile PC, messaging, TV/Streaming and downloads). Both of these trends are in great correlation with Tesla's statement about his wireless system from 1900.

Activities and trends in wireless communications can be illustrated with the situation in year 2005 and with the achievement in June of year 2006 where the complete wireless community reached 2 billion users (GSM world web reference). Figure 2 illustrates this situation.

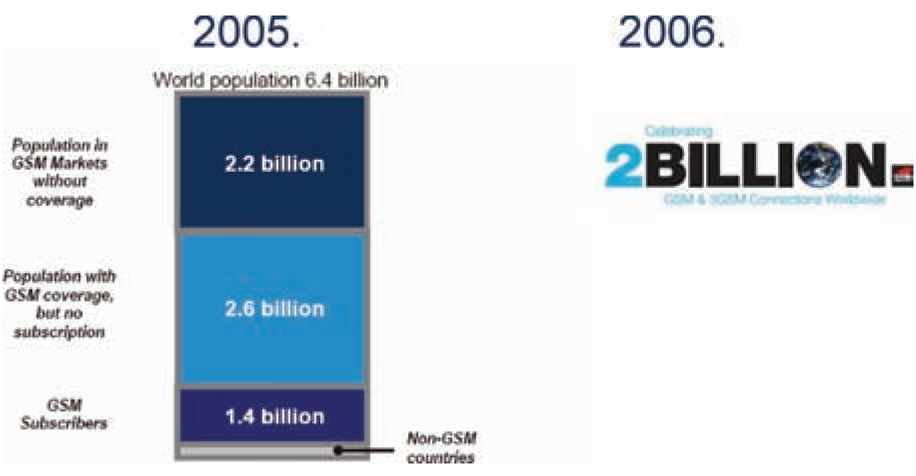

Figure 2. Users of GSM technology

As is visible on the first chart in Figure 2, for the year 2005 the dominant technology for wireless communication around the world was GSM. There were 1.4 billion GSM subscribers of the total world population of 6.4 billion. 2.6 billion of the population have the possibility to be subscribers because they have coverage with wireless signals but they are not subscribers yet. There is still 2.2 billion of the population without the possibility to be a subscriber because they do not have an infrastructure and access to a wireless network signal. Another visible thing on second part of Figure 2, year 2006, is that in less than one year there has been a growth in subscribers of approximately 43 percent, moving us closer to enabling as much of the population as possible to communicate. The main benefit of wireless systems is especially in poor countries to faster establishing communication infrastructure to have today civilization possibilities. It is visible that today GSM and 3G networks are gaining new subscribers at the rate of about 1000 per minute, with the total recently passing the 2 billion mark. Inline with the current population trend and acceptance of wireless communications, the expected amount of wireless subscribers is 4 billion.

Today's driver of mankind wellness is to have information at the right time or whenever you need it and wherever you are located. There are so many sources of information but in general we can divide them in correlation with our home or in correlation with our office or business environment. Life is today much connected with constant mobility and many of us are owners of mobile terminals that enable us to cover these two main daily requirements – possessing of information and mobility. The concept that best enable us to fulfill these two requests is called triple play communication environment as illustrated in Figure 3.

Figure 3. Triple play concepts

This concept of triple play forces the new convergence of different sources of information with all needed requests for office and for home. What we prefer the most at home regarding communication services are telephony, or voice communication, access to web sources of information and TV. At the office environment we prefer to use telephony and web-based services. All together we can converge on our mobile terminal device and we can be independent of our location availability. Communication technology enables us to use different terminals but at the same time to have only one of them and to have full access to our preferable communication services. Thanks to Tesla and his great invention of the wireless communication principle.

4. Tesla's "World system"

The previous chapter enlightened only a part of Tesla's invention and vision regarding the area of communication. If we take 12 basic elements that Tesla wrote in articles, in the year 1902, 1915, and 1927, about his prediction about the "World System" we can see many visions of today technological elements and communication infrastructures trends. Tesla called these statements Action Plan.

Tesla's statements (D. Mitchell, 1972):

1. Interconnection of the existing telegraph exchanges or offices all over the world;
2. Establishment of a secret and non-interferable government telegraph service;
3. Interconnection of all the present telephone exchanges or offices all over the globe;
4. Universal distribution of general news, by telegraph or telephone in connection with the Press;
5. Establishment of a World System of intelligence transmission for exclusive private use;
6. Interconnection and operation of all stock tickers of the world;
7. Establishment of a world system of musical distribution, etc.;
8. Universal registration of time by cheap clocks indicating the time with astronomical precision and requiring no attention whatever;
9. Facsimile transmission of typed or handwritten characters, letters, checks, etc.;

10. Establishment of a universal marine service enabling navigators of all ships to steer perfectly without compass, to determine the exact location, hour and speed, to prevent collisions and disasters, etc;
11. Inauguration of a system of world printing on land and sea;
12. Reproduction anywhere in the world of photographic pictures and all kinds of drawings or records.

Analysis of these statements can be done in many different directions, but in all of them there is a visible common denominator: the phrase world or around the globe, which can be interpreted as to all community. Another important visible fact is at the mentioning at that time of important communication principles such as telegraphy and telephony, with some important technology visions. Some of these technology visions were realized in the next couple of years but some of them in fifty years, for example statement five that predicts today's Internet and World Wide Web technology, or today very popular electronic music distribution. Looking from today's perspective we can say that all visions/statements are basically achieved in the context of technology but not all of them have reached global presence, especially in the context of being available to everyone as meant by Tesla with "World System".

Based on this last conclusion, with exclusion of some elements in connection with telegraphy that is in minor usage today, we can consider these statements as a communication manifest to enable global wellness to everyone. That was Tesla's background visions in his many technological inventions.

To discuss a little bit more the impact of ideas from Tesla's "World System", an important fact comes from his additional statement in the article (N. Tesla, 1900):

"*… the distribution of wireless energy for all purpose the precedent established by telegraph, telephone and power companies must be followed, for while the means are different the service is of the same character.*"

Thinking about this statement and putting it in today's context, the idea was to make a graphical presentation as illustrated in Figure 4. Analyzing things in illustrated context it is visible that the starting point is with a couple of technological elements that was based on the concept of wireless energy transmission. After that come many development elements and trends that enable infrastructure to transmit and use this wireless energy. With all convergence trends, some of them are mentioned in the

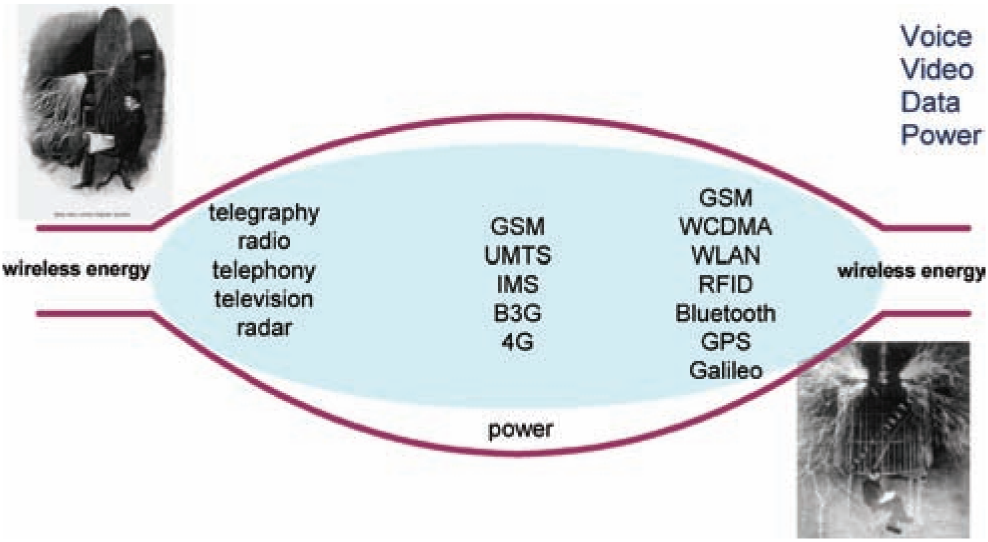

Figure 4. Wireless energy transmissions

previous chapter, in the infrastructure and terminals the end point is very simple and once again in the concept of wireless energy transmission.

There are a lot of technological elements merged in the same context of wireless energy transmission, as Tesla wrote: "… service is of the same character". The basic start is in principles of telegraphy, telephony, radio, television and radar. In the middle are basic principles for infrastructure that enables building the broader, around the globe, transmission environment – network as from GSM to 4G. At the right side are some additional technological elements that enable basic wireless access or some additional data transmission such as positioning data. An additional element in the same context is electrical power. All of these elements and principles are used to transmit voice, video, data or power. All of these principle realizations will help in complete fulfillment of Tesla's statement about a World System and his visions about the role of communication for global wellness.

5. The communication grid

Analyzing Tesla's visions and invented principles in the aspect of communication and AC electrical power production and distribution it is important to think in a similar context. We have today an electrical power grid that provides to us pervasive access to power. This means that wherever we are in an urban area we can plug in our device and start to use AC electrical energy. The distribution systems for electrical energy are well connected around the globe and we do not ask where is this energy produced – we just use energy. The established system gives to us a lot of freedom.

Basic understandings of the electrical power grid and the needs for complex and demanding computing lead the science community to start to build a computing grid. The basic idea is to use computing power in the connected environment independent of the capabilities of our own computing device. Grid computing is an emerging computing model that provides the ability to perform higher throughput computing by taking advantage of many networked computers to model a virtual computer architecture that is able to distribute process execution across a parallel infrastructure. Grids use the resources of many separate computers connected by a network (usually the Internet) to solve large-scale computation problems. Grids provide the ability to perform computations on large data sets, by breaking them down into many smaller ones, or provide the ability to perform many more computations at once than would be possible on a single computer, by modeling a parallel division of labour between processes (I. Foster, C. Kasselman, 1988).

Based on our previous analysis about where we are now in communication technology development and what we tend to achieve in the research and development community, it is more than obvious that we want to have a communication grid. This means that we want to be reachable anywhere, anytime with our preferable services. The question can be how is this correlated with Tesla? The answer is that Tesla provided the deep roots with his basic invention of wireless communication and through his vision statements about communication aspects. It enables many other inventors and companies to produce technology that will enable us to have the full scope of a communication grid.

5.1 Synergic effect

One additional idea pops up through this analysis that can be called synergic effect between energy usage and rich communication. To elaborate possible synergy between these two things it is important to repeat today life motto: everyday life fully depends on information and everyday work depends on communication. We are using a lot of nature resources, energy, to commute and meet together to do the job. We are all aware of price of petroleum and problems of natural reserves of crude oil. The question is can we change something? For sure we are trying to find some alternative energy sources. Another possible direction can be to make a saving in energy usage but in the same time to have at least equivalent or better possibilities to be in contact through the richer and omni presence communication possibilities. The basic idea is illustrated on Figure 5.

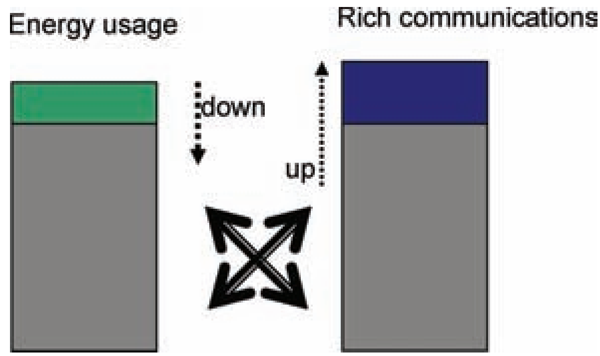

Figure 5. Synergic effect

This idea is called synergic effect because enabling richer communication will lead us to less energy usage. Executing the concept of communication grid, that is in full track of Tesla's vision and inventions will fully cover the idea of synergic effect and can be good to all community.

5. Conclusion

Analyzing Nikola Tesla from the aspect of communication he can be perceived as a man of visions, and the statement from the introduction of this article: "… Nikola Tesla paved the way for modern technology" can be fully proved. Taking into account his great contribution to the AC electrical power systems it is visible that as AC electrical energy was important in enabling mankind wellness, or commodity, in the previous century, modern communication and especially wireless communications have become a commodity of 21st century. Full commodity of wireless communications will be achieved when it will be possible to have broad deployment of rich multimedia communications that will enable the communication grid concept. Tesla's visions in the area of communication inspire us a great deal, and we have a couple of things to make operable still. We will prove Tesla's statement by building the communication grid and enable the full scope of wireless energy transmission.

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Evolution Trends of the Converged Networks and Next Generation Networks

Abstract

The evolution strategy of the converged networks towards the Next Generation Network (NGN) architecture is presented in the article. The up to date outputs and results of the standardization institutions: International Telecommunication Union – Telecommunications (ITU-T) and European Telecommunication Standards Institute (ETSI) in the area of the converged networks and NGN, as well as the research and development activities and trends of main Information and Communication Technologies (ICT) producers are taken into account in the formulation of migration scenarios and development processes of the possible conception of the future NGN architecture. Using the actual NGN conceptual model the distributed conception of the NGN architecture (individual network layers) is shortly described. Migration scenarios of IN evolution towards platforms of Converged Networks and NGN are presented. Key aspects of the evolution trends of the ICT towards NGN are also introduced. Within the presented case study, some results of the state research and development project are presented.

Key words

Next Generation Networks platform, migration scenarios, IN and IP convergence, NGN services and applications.

1. Introduction

*"**NGN** is a concept for the defining and establishing of the networks, allowing a formal distribution of functionalities into separate layers and planes by using open interfaces, making it possible for the service providers and operators to create a platform which can be gradually developed thanks to creation, implementation and effective management of innovative services"* (Source ETSI).

The trends of the convergence touch several levels, at which the process of convergence can take place within the communication networks. To understand the significance and principles of the converged technologies, the platform of the existing networks and principles of their functioning should be outlined briefly.

It is necessary to be aware of the fact that the majority of the current communication networks serve for a certain specialised communication:

- PSTN (Public Switched Telephone Network) – a public telecommunication network for voice transmission and voice services (even if it allows also modem connection for data transmission and fax service, respectively, and after ISDN deployment also other additional services), value-added services (in fact voice again) enabled the development of intelligent networks (IN).
- Data networks – designed for data transmission, which have requirements different from those for voice transmission. The most widespread representatives are the local computer networks (LAN) and the Internet.
- Radio and television – unidirectional broadcasting point-multipoint.
- Mobile networks – voice transmission also data transmission and 3G services; allowing the subscriber's mobility.
- Satellite technologies – wide spectrum of services and applications.
- A lot of other networks with a specific architecture and different principles of operation, transmission media and they use various protocols for communication and management.

Let us give at least the most frequently presented reasons substantiating the need of the new generation network platform:

- Several specialised networks for a certain type of services, some of them being ineffective to be developed; it is necessary, however, to ensure their tasks.

- Each network platform has, more or less, its own architecture and specificity, though it does not cover all communication needs.
- Duplicity of resources, vertical architecture, in terms of prices less effective.
- More complicated securing of Network Management System – NMS and operation as well.
- Reduction of costs of infrastructure and a more flexible development of the network and services as well.
- The need to respond more flexibly to advancement within the ICT technologies development.

Converged networks should enable interconnection and co-operation of various types of communication networks while preserving the features necessary for ensuring the various media transmission.

The result of the definition is that one should be aware of different **views of convergence**:

1. One view is the convergence of various types of data that are transmitted/transferred via communication environment, be it voice, audio, video, text or multimedia. Each type of media has different requirements for transmission medium: bit-rate (bandwidth), delay, bit-rate error, etc. Thus there are several categories of services for which the defined network parameters must be complied with, for example Quality of Service – QoS (Kvackaj and Baronak, 2004).

2. Interworking of two different types of networks: connection-oriented with circuit switching (PSTN) and connectionless with packet switching (IP) requires the ensuring of the interconnection at the transport level (conversion, transmission/transfer, routing), as well as at the signalling level (controlling level) – control of service connection and management.

3. If the points 1 a 2 are complied with, it is possible to design a converged network which will allow, in the framework of a single architecture, to connect and integrate various types of networks into one universal broadband multimedia network, designed for transmission of all the types of media and for provision of a wide range of services and applications.

In this paper, some research approaches and activities of the national integrated team of ICT experts from Slovak universities and research institutes focused on the creation of the conceptual model and reference architecture of the NGN platform in the environment of the ICT infrastructure of the Slovak Republic are presented. These activities have been realized within the research and development project "Convergence of the ICT networks and services in the Slovak communication infrastructure" granted by Slovak Government within the State research and development programme "Building of information society" (NGN, 2006).

This paper is focused on the following topics and processes:

- NGN concept and architecture,
- Migration scenarios in ICT convergence processes,
- PSTN and IP convergence,
- Evolution trends of the ICT towards NGN,
- NGN platform at STU Bratislava (case study).

2. NGN concept and architecture

All activities of the research team involved in the development of the conceptual model and reference NGN platform architecture of the Slovak ICT infrastructure have correlated with the actual outputs of the international standardisation institutions ETSI and ITU-T.

NGN definition

Opinions on NGN definition may differ in some ways, but the main principles of the NGNs (Next Generation Networks) were formed when the idea of NGN itself emerged. The next two definitions describe NGN in substance.

(ETSI, 2001): ***NGN*** is a concept for the defining and establishing of the networks, allowing a formal distribution of functionalities into separate layers and planes by using open interfaces, making it possible for the service providers and operators to create a platform which can be gradually developed thanks to creation, implementation and effective management of innovative services.

Another standardization institution ITU-T, which within the NGN 2004 project adopted new recommendations (in 2004), goes further in its definition and defines NGN as follows:

(ITU-T, 2004): ***NGN*** is a network based on packet transfer, enabling to provide services, including telecommunication services, and is capable of using several broadband transmission technologies allowing to guarantee QoS. The functions related to services are at the same time independent of the basic transmission technologies. NGN provides unlimited user access to different service providers. It supports general mobility providing the users with consistency and availability of services.

2.1 NGN conceptual model

There are many conceptual models and reference architectures for both the converged networks and VoIP architectures, therefore, we have tried to find common features and to define a suitable conceptual model for NGN. An objective of the ***conceptual model*** is to determine functional layers (covering similar functionalities), their entities, reference points (interfaces) and information flows between them. Such a model then can be mapped more easily into the physical reference architecture (and it is independent of the physical entities, i.e. components of the architecture).

In most analyzed cases the **NGN conceptual model layers** are from the point of view of functionalities divided into independent parts as follows (Fig.1): access (some reference architectures do not include it directly into

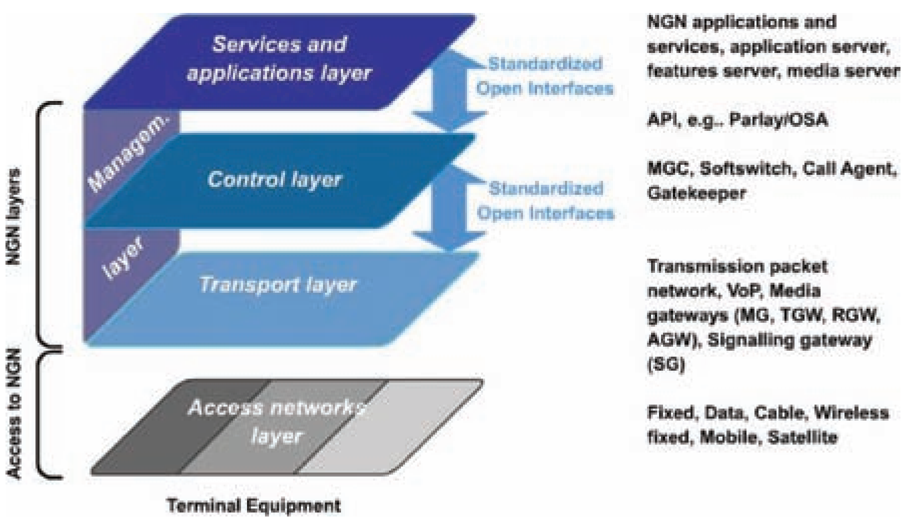

Figure 1. NGN conceptual model

the NGN model or replace it by the adaptation one), transport (transmission, switching), control (call/sessions control) and application (services).

Conceptual model layers

General tasks of individual layers.

The access layer provides the infrastructure, for example an access network between the end user and the transport network. The access network can be both wireless and fixed and it can be based on various transport media.

The transport layer ensures the transport between the individual nodes (points) of the network, to which access networks are connected. It connects physical elements deployed in the individual layers It also enables the transport of different types of traffic, media (signalling, interactive data, real-time video, voice communication, etc.)

The control layer includes the control of services and network elements. This layer is responsible for set-up/establishing, control and canceling of the multimedia session. It ensures the control of sources as well, depending on the service requirements. One of the fundamental NGN principles is the separation of control logic from the switching hardware.

The service layer offers the basic service functions, which can be used to create more complex and sophisticated services and applications. It controls the progress of the service based on its logic.

In the NGN it is required that the network control is not determined only by the terminal equipment applications, but that the network intelligence may carry out control over the network at all levels of the reference model.

The network management reference model implies the following ***tasks for the network intelligence*** it has to ensure:

- Resource management (capacity, ports, physical elements) and QoS in access to the network and in the transport network, as necessary.
- Various media processing, encoding, data transfer (information flows).
- Management of calls and connection. Management and interworking of all elements of the reference architecture.
- Service control.
- Information and network security.

The research activities of our research team has been focused on the wide spectrum of problems concerning the convergence processes of the different types of the ICT networks towards the NGN platform. The activities of the international standardisation institutions (ETSI a ITU-T), as well as the actual state in the area of standardisation have been strictly taken into account by the research team.

In the development process of the conceptual model and the reference architecture of the Slovak ICT infrastructure, the project research team accepted the following two concepts of the NGN architecture:

- Concept of multimedia IP subsystem – IMS (3GPP),
- Concept of TISPAN.

2.1.1 Concept of multimedia IP subsystem – IMS (3GPP)

The initiative of organization institutions 3GPP within the specifications of UMTS architecture (3GPP within the UMTS architecture 5/6 (3GPP, 2005) has defined two domains:

- Circuit switching domain,
- Packet switching domain.

The packet switching domain extends the existing GSM network and other mobile 2nd generation (2G) networks by the CDMA-based access, while the packet switching domain extends the abilities of the GPRS and other systems of 2.5 generation.

The subsystem for supporting multimedia services, telephony and IP-based message sending, designed in the framework of the packet switching domain is called IMS (IP Multimedia Subsystem). IMS is based on the IP architecture for multimedia and it was placed as a supporting network element to provide standardised and universal services for mobile users. As it was one of the first concepts on which all the standardisation institutions agreed and which conformed to the NGN principles, it is becoming one of the reference concepts for the fixed networks as well.

The IMS concept is based on 3 layers (application, session control, media and access). The basic above-mentioned entities can be seen in Fig.2. A simplified IMS version is applicable also for the fixed networks.

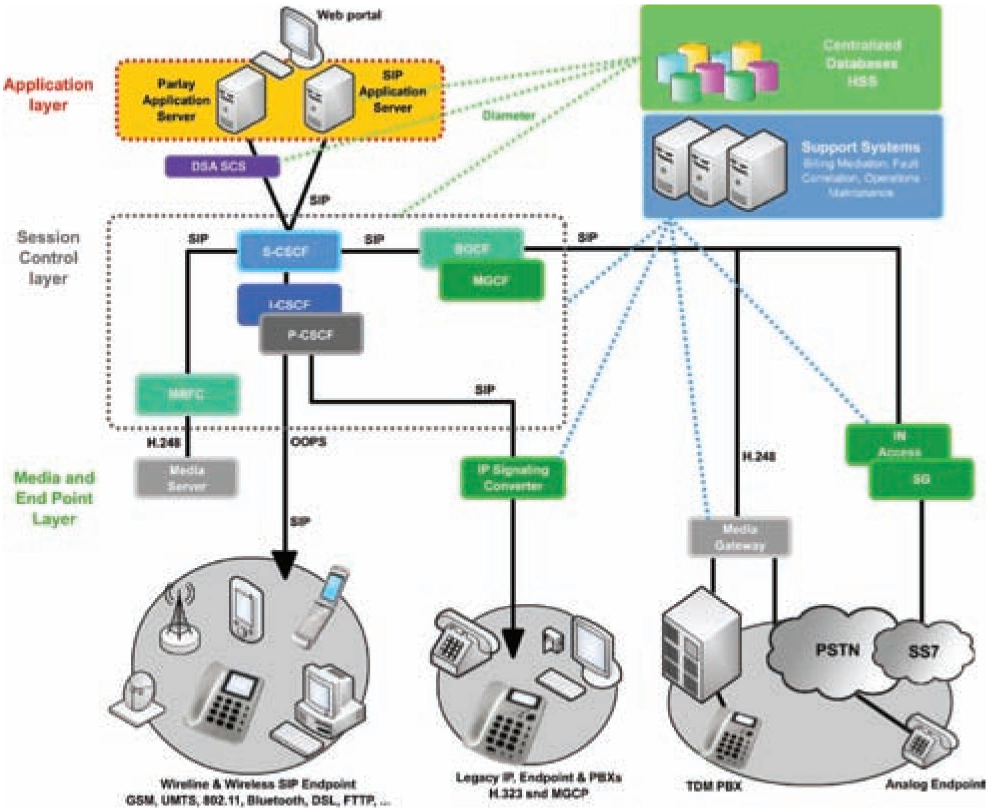

Figure 2. Multimedia IP subsystem (IMS)

2.1.2 Concept of TISPAN

The TISPAN network architecture is based on 3GPP IMS, which is a basis for control and provision of the real-time conversation services (based on SIP protocol) (TISPAN, 2006). 3GPP IMS architecture is extended in TISPAN NGN to support various types of access networks, such as xDSL, WLAN, etc.

TISPAN architecture is extended mainly by:

- access networks control (QoS, access control and authentication),
- co-ordination of various control subsystems via one transport network to control resources,
- interworking and interoperability with public networks (legacy networks),

- separation of the application layer from the connection control layer and the transport layer,
- independence of access technologies from the call control layer and the application layer.

For services on other than SIP basis, the TISPAN NGN architecture can include other subsystems defined in TISPAN (TISPAN, 2005). Fig. 3 illustrates the NGN components and functionalities.

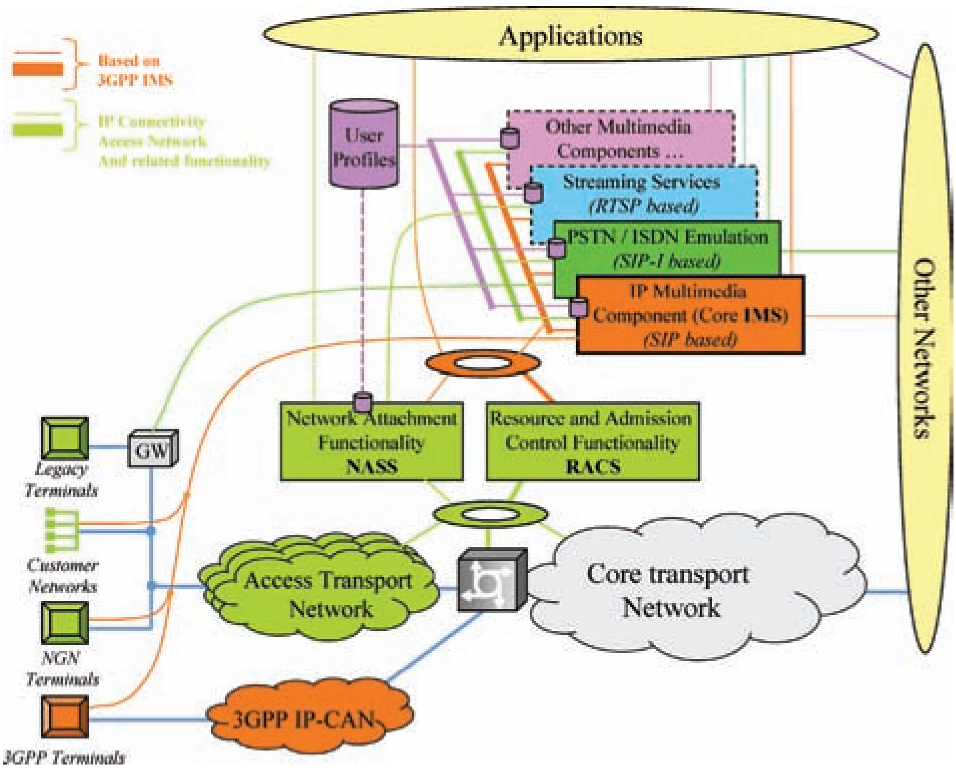

Figure 3. Architecture of a TISPAN NGN

3. Migration processes and scenarios of ICT networks

The Fig. 4 shows possible migration scenarios of different types of ICT networks to NGN. We must, however, realise that the process of migration is a network evolution rather than revolution. The method how the existing technologies and networks will converge in the migration process to NGN is also important.

The following migration scenarios can be seen from the Fig. 4:

PSTN and IN towards NGN
• hybrid networks
• VoIP networks
• NGN

Internet and data networks
• Internet telephony
• VoIP networks
• NGN

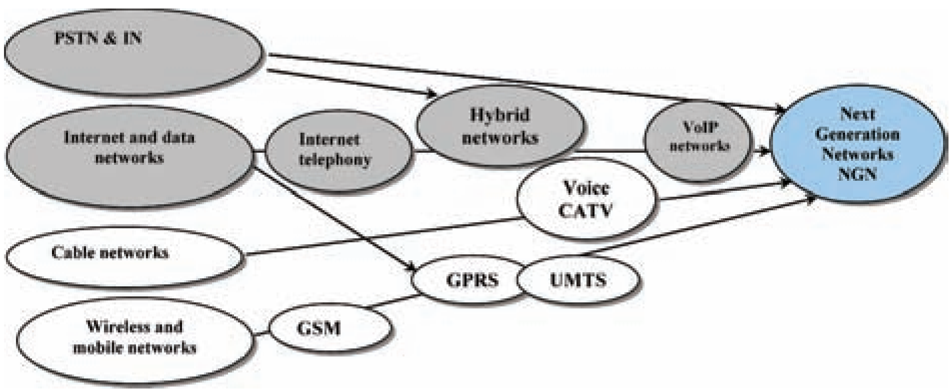

Figure 4. Migration scenarios of networks convergence and NGN

Cable networks
• Voice CATV
• NGN

Wireless and mobile networks
• GSM
• GPRS
• UMTS
• NGN

Modernization and introduction of the NGN can be carried out by several basic procedures of migration, or by their combinations. The first method of migration is the overlaying of the existing network by a new one. The other method uses replacement of separate parts of the network by the new technology. This replacement may be designed according to various criteria (geographical, needs for modernization, market potential, etc.).

In the following chapter the possible migration scenarios of the PSTN and IP networks, as well as the migration of mobile networks towards NGN are shortly described.

4. PSTN and IP convergence

When we speak about the PSTN evolution towards NGN , then we have in mind one of two possibilities that are offered at present for the improvement of PSTN platform capabilities/facilities. One of them is the use of intelligent networks platform, allowing the co-operation with the networks of other types, e.g. mobile (in the form of FMC – Fixed mobile Convergence), packet (IN-IP co-operation), broadband (BIN – Broadband Intelligent Network). The other possibility is to replace and modernise the existing PSTN by implementing the NGN functional elements. For example, exchanges concerned will be extended by hardware modules that will perform the functions of media gateway, or new network elements will be incorporated into the network.

In the development process of the reference architecture of the NGN platform in the environment of the ICT infrastructure of the Slovak Republic the following migration scenarios of the PSTN have been taken into account:

- PSTN/ISDN convergence
  - PSTN/ISDN *Emulation,*
  - PSTN/ISDN *Simulation,*
- PSTN/IN convergence
  - IN migration towards BIN (Broadband Intelligent Networks),
  - IN&IP covergence:
    - Hybrid networks (IN and Internet),
    - IN&VoP,
    - IN towards NGN,
    - NGN with integrated IN platform.

The Fig. 5 illustrates the possible physical architecture of the NGN platform from the point of view of the PSTN and IP convergence.

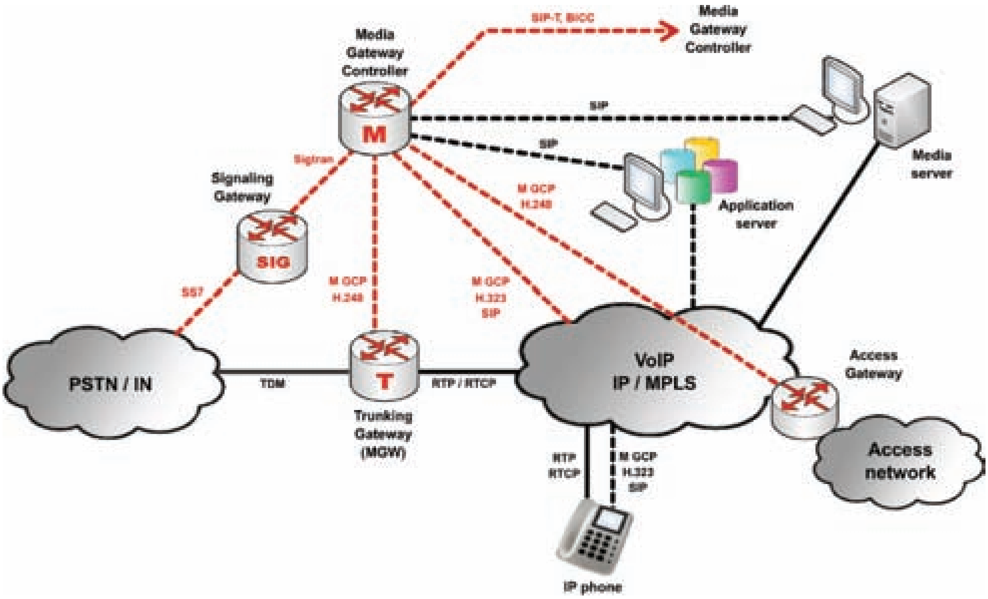

Figure 5. An example of NGN physical architecture

4.1 IN&IP convergence

In the convergence process of the PSTN and IP, the IN – Intelligent Networks and IP networks convergence plays the key role. The research team participating in the research and development project "Convergence of the ICT networks and services in the Slovak communication infrastructure" concentrate it`s activities also to migration scenarios of the convergence IN towards NGN.

We are focus on the development of the conception, how IN effectively migrate to NGN. All research and development activities accepted the actual activities and outputs of the standardization institutions ITU-T and ETSI.

Two different ways of evolution we can recognize from standardization processes (Fig.6.). First path is migration to the broadband network like B-ISDN and the second one is migration towards NGN.

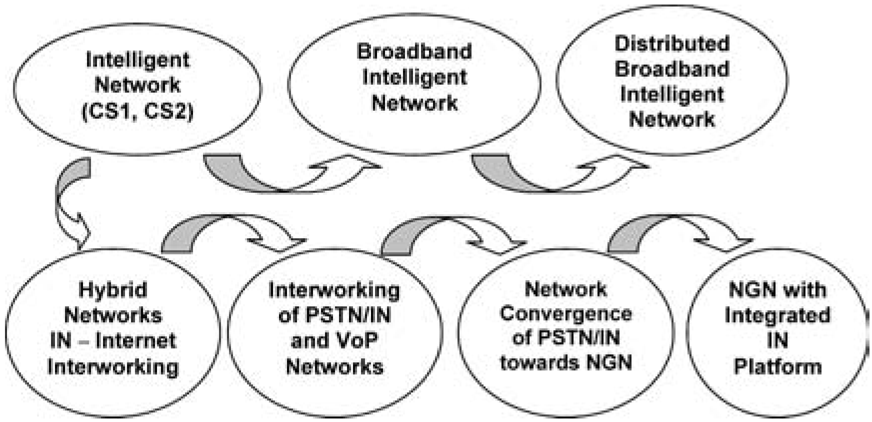

Figure 6. Migration process of IN evolution towards platforms of Converged Networks and NGN

Intelligent networks should evolve to two broadband platforms based on ITU-T recommendations:

- Broadband Intelligent Network (BIN),
- Distributed Broadband Intelligent Networks (DBIN).

Main stream of the IN evolution is oriented towards converged IP based networks and to NGN.

One of the first evolution stages aiming to co-operation of IN and IP networks may be denoted the IN/Internet interworking which offers so-called platform of hybrid network and allows access to IN functionalities through Internet.

Real convergence is coming with interworking of PSTN/IN and Voice over Packet networks (VoP).

The Fig. 7 depicts the co-operation of PSTN/IN network and voice-transmission-supporting packet network (Baronak and Halas 2004). The architecture of converged networks consists mainly of packet network supporting multimedia communication and it is derived from architecture for voice transmission (VoIP).

Different steps of convergence and migration models of IN platforms to NGN architecture are described also in ITU-T recommendations within CS-4. We are designed the concept of reference architecture as it is shown on Fig. 8 based on IN-IP converged architecture in Q.1244 (Q.1244,

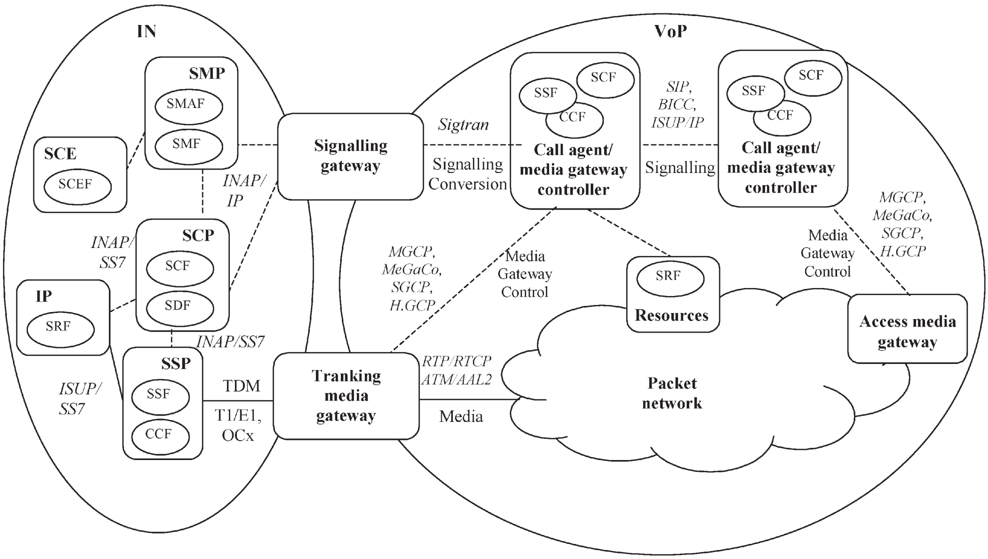

Figure 7. Co-operation of PSTN with V oP

2001). The reference architecture is based on principles of the distributed architecture and open API (Application Programming Interface). SA-GF (Service Application Gateway Function) provides interworking between

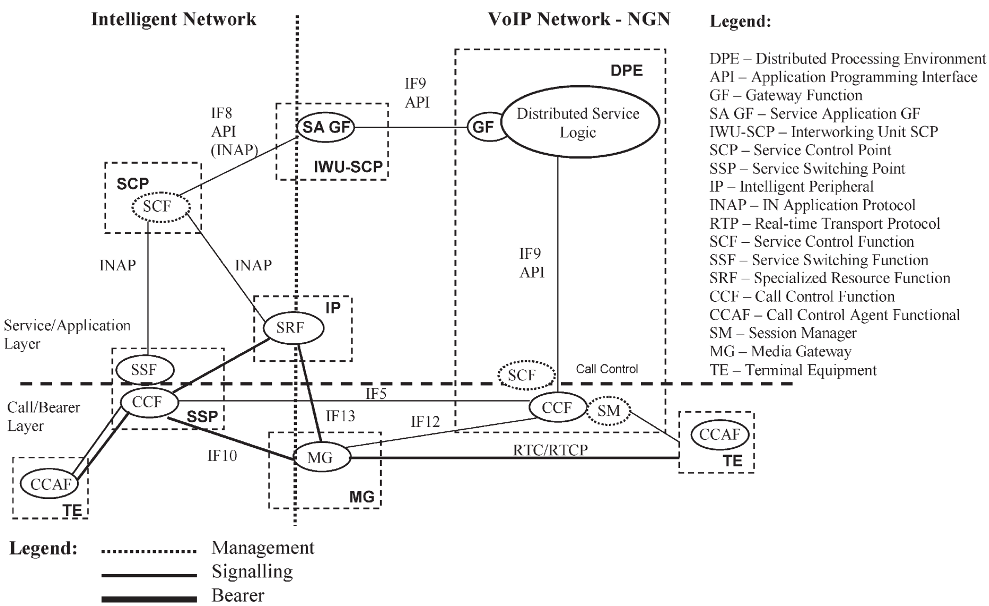

Figure 8. Integrated IN and VoP reference architecture (mapping of FEs and PEs)

IN service logic and distributed service logic located in NGN. This kind of solution brings advantage to both domain IN as well as external domain DPE (Distributed Processing Environment). The external domain can use resources located in the IN (e.g. Interactive Voice Response, control of establishing call within IN). The external domain is also informed about session state or incoming calls from IN, etc.

The SCF to SA-GF interface is provided the access to distributed service logic via an API. As such, the "distributed service logic" may be resident within one Network Operators domain, or may be provided by a 3rd party such as a Service Provider. Either way the SA-GF will provide the necessary firewall/security functions to protect both the IN network provider and the 3rd party service logic provider and any protocol mapping functionality deemed necessary.

The Service Application Gateway Function allows:

- interworking between the Service Control layer in the Intelligent Network and the Distributed Service Logic.
- interworking between the Call Control Function and Distributed Service Logic.

For IN CS-4 at the application level, the types of ANI based functionality may include, CORBA, JAVA, JAIN technologies or other API based platforms. Additionally this functionality may provide protocol mapping/service mediation.

We choose the concept of IWU-SCP (Interworking Unit SCP), which plays the role of SA-GF within preferred reference architecture based on Q.1244 recommendations. The distribution of functional entities is illustrated in Fig. 8 and explains principles of distributed service logic over two domains and call control decomposition over different physical entities.

NGN with integrated IN platform

Intelligent network services can be implemented in NGN service layer as services and applications within functionalities of application server. Existing components of IN platforms is integrated to NGN via IM SSF (IP Multimedia SSF), which provides access to service logic implemented in the IN SCP. The IM-SSF functionality forms emulation of IN call model (Basic Call State Model – BCSM) over SIP signaling, IN triggering, IN management features mechanism, emulation IN SSFSM (Service Switch-

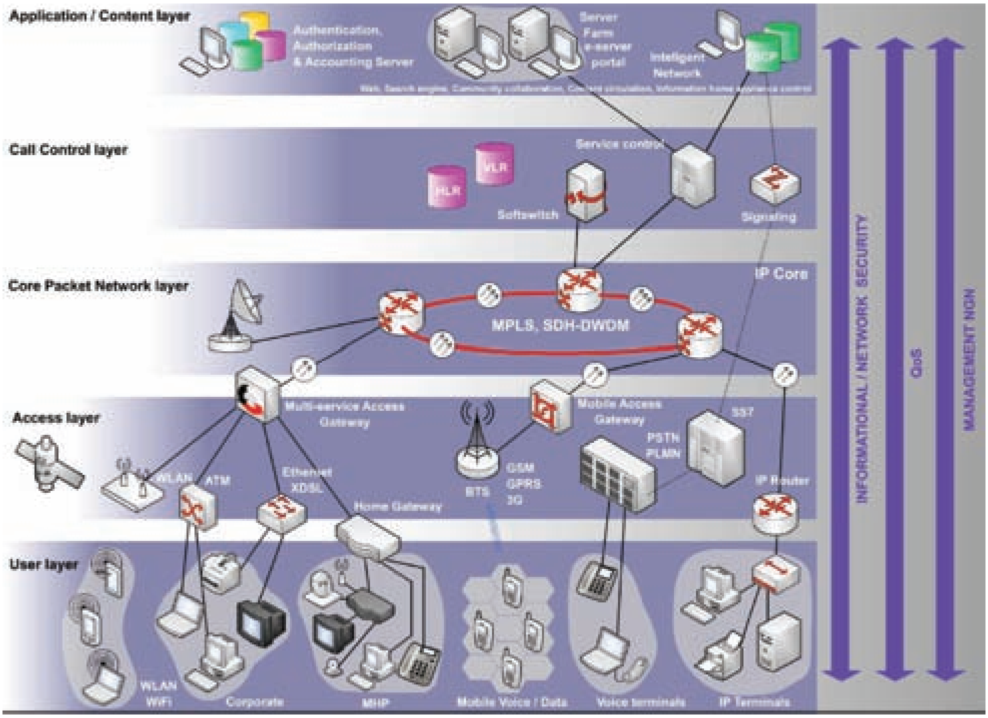

Figure 9. NGN conceptual model with IN integrated platform

ing Finite State Machine) and interworking with PSTN/IN through INAP signaling. Fig. 9 represents the NGN conceptual model with IN integrated platform.

4.2 Migration of mobile networks

One migration scenario of the convergence process of mobile technologies to NGN is illustrated in the Fig. 10. It is about the interconnection of

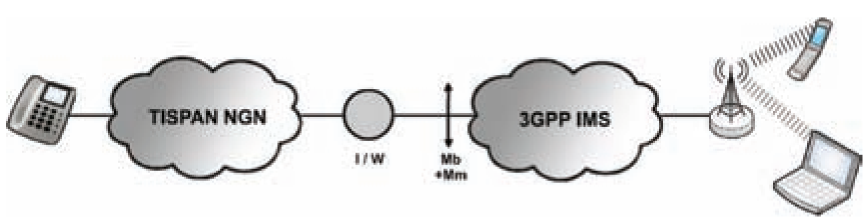

Figure 10. Interconnection of NGN with mobile networks GSM, GPRS, UMTS – 3GPP IMS

the NGN platform with mobile networks GSM, GPRS, UMTS – 3GPP IMS.

On part of 3GPP the interconnection is ensured on the interfaces defined within IMS architecture as Mb interfaces (for transmission) and Mm interfaces (for management).

5. Evolution trends of the ICT towards NGN

Main trends and challenges determining the development in the field of NGN technologies (OECD, 2005) may be observed with respect to changes taking place in the environment of telecommunications.

On one hand the changes affect the conditions and environment in which operators perform their activities, namely the competition at the telecommunication markets, as well as the activities of regulation authorities and standardisation institutions. The declension of the voice services is compensated thorough implementation of new services including the broadband ones.

The second influencing factor, however, is also a change in customers behavior and the change in telecommunication services users' requirements. A lot of users with Internet access prefer charge-free communication services among individual Internet users. Here belong Internet applications of instant-messaging type (ICO, Jabber) or VoIP calls (Skype, SIP phone sets) or P2P file sharing. There exists also significant rising trend in using the mobile communication and implementation of new mobile technologies enabling to expand the offer of mobile services. Users demand lower-and-lower priced, user-friendly and comfort services which would be more flexible from the viewpoint of given functionalities.

The last, but not less important factor is development of technologies in the field of telecommunication services. Expansion takes place also in the area of new technologies enabling the provisioning of the wider spectrum of services for higher number of users and on lower cost compared with current technologies. New access network technologies support the high speed data transmission in direction to the end user (both fixed – xDSL, FTTx, FWA, and mobile 3G-UMTS, Wimax, Wi-Fi). Cost of transport network is on the decline by deployment of more powerful and cheaper optical networks.

Influencing factors and changes supporting the implementation of new progressive technologies can be quantified from the viewpoint of the following trends:

Structural changes on telecommunication markets:

- a decline in number of users and revenues from PSTN,
- increasing competition, privatisation of national operators and liberalisation,
- markets de-regulation, e.g. local loop unbundling,
- globalisation.

Changes in service users requirements:

- quick growing of broadband Internet,
- VoIP-based services,
- mobile services 3G, WLAN, Wi-Fi, WIMAX,
- Digital TV.

Technological evolution:

- creation of innovative, interoperable and sizeable IP-based solutions,
- onset of IPv6,
- digitalisation and replacement of TDM solutions by IP-based solutions,
- increase in CPU performance, memory capacity and functionalities of components and terminal equipment units,
- implementation of the fibre optics and optical components.

These trends, however, also bring a lot of open questions and relevant requirements. It is necessary to find a suitable ways of migration towards application of new technologies and network platforms while maintaining, or even expanding the scope and quality of provided services. There may be mentioned two principal points which shall be solved by the operators:

- economy-business from the cost-effectiveness viewpoint,
- competitiveness (ability to compete).

Challenges waiting to the operators in the field of NGN technologies might be briefly summarised in the following points:

- Challenges of the economic & business character:
  - solution of financial problems on the part of telecommunication operators (a decline in revenues; high operation cost),
  - elimination of doubts concerning the business models,
  - openness of services for third-party providers .
- Challenges of the technical character:
  - end-to-end QoS,
  - overload & bandwidth management,
  - security,
  - interoperability,
  - robustness, reliability, capability to maintain quality and network integrity,
  - improvement of network management systems,
  - support of user mobility,
  - standardisation, support of protocols,
  - openness of solutions.

6. NGN platform at STU Bratislava (Case study)

One of the key outputs of the research and development project "Convergence of the ICT networks and services in the Slovak communication infrastructure" acting within the State research and development programme "Building of information society" the pilot NGN platform has been build up. This platform has distributed architecture. The operational and management platform is located at Telecommunication Department of the Slovak University of Technology in Bratislava. The segments of this NGN pilot platform are dislocated at TU Kosice and University of Zilina. The individual segments of the NGN platform are interconnected via 2 Gbit IP Slovak Academic Network (SANET).

The segment of the pilot NGN platform at the Telecommunication Department of the Slovak University of Technology in Bratislava consists from two parts:

- pilot NGN platform with operational and management segment supports the research and development activities in the wide spectrum of topics:

  - components and network segments of the NGN platform,
  - NGN platform protocols (call control protocols, media gateway control protocols, protocols for signalling transport, transport protocols, protocols for QoS support),
  - interconnection of the individual distributed segments of the pilot NGN platform,
  - NGN services and applications implemented in the NGN pilot platform environment,
- NGN Lab with the conception supporting research and development activities, as well as educational activities.

The pilot NGN platform integrated into the ICT infrastructure of the Telecommunication Department of the Slovak University of Technology in Bratislava (STU) is illustrated in the Fig. 11.

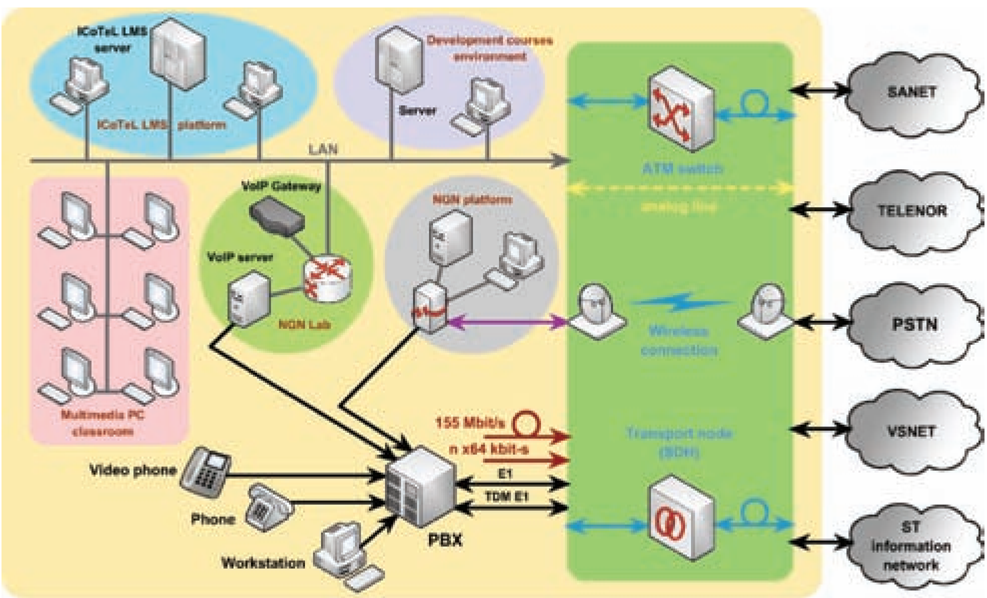

Figure 11. ICT infrastructure of the Telecommunication Department of STU Bratislava

Because the configuration of the NGN Lab was developed the way, to support the research and development activities in the area of NGN, as well as the educational activities based on e-learning, the conception of the NGN lab platform and activities supporting by the NGN Lab are described below in more details.

The configuration of the physical architecture of the NGN Lab is illustrated in the Fig. 12. The Fig. 13 provides the complex view on the physical architecture NGN Lab and e-learning platform from the point of view of the NGN architecture conceptual model. The right side of the Fig.13 represents the public segment of the NGN ICT infrastructure platform. The left side of this figure represents the physical architecture of the NGN lab and e-learning platform at Telecommunication Department of the STU Bratislava. The following can be seen in the Fig. 13:

- possible configurations of end users equipment, multimedia PC class rooms, videoconference room and further terminals implemented at the user layer,
- conception and configuration of individual segments of the access network (at the access layer),
- network architecture of the transport layer,
- network components placed at the control layer, that support the control and management processes,

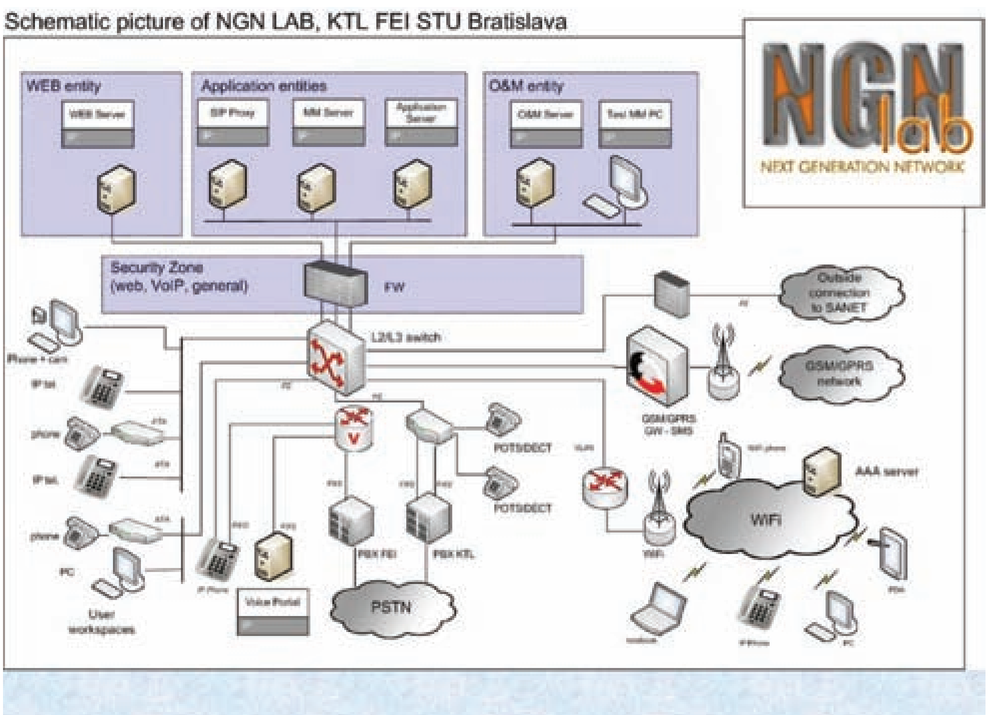

Figure 12. Configuration of the NGN Lab platform

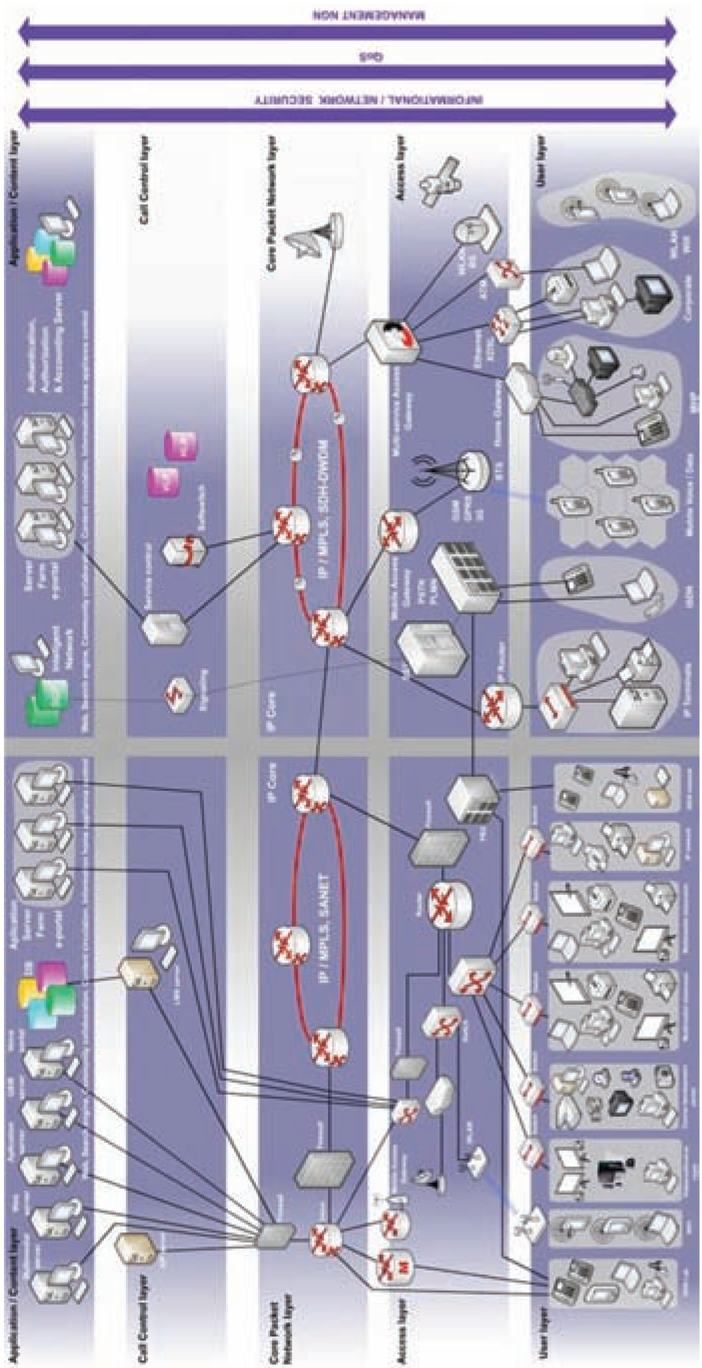

Figure 13. Physical configuration of the NGN Lab and e-learning platform (including network interconnection)

- set of servers and disc arrays serving databases located at the application layer (application servers, web server, multimedia server, voice portal, O&M server, e-learning database),
- connectivity of the NGN Lab and e-learning platform with public ICT infrastructure.

The application layer of the NGN Lab and e-learning platform is developed the way to support the wide spectrum of NGN services and applications. The following services and applications are implemented at above mentioned servers and databases:

- NGN web based applications (Content management system ; groupware applications, like a personal calendar, addressbook, project manager, forum, trouble ticket system; e-learning, manager your VoIP account),
- NGN communication applications (voice calls ,video calls, messaging),
- NGN Multimedia services (video streaming, voicemail, video conferencing).

The users can access via NGN Lab portal (Fig. 14) to individual services and applications implemented in the NGN Lab environment, as well as to collaboration tools and further functionalities provided by NGN Lab.

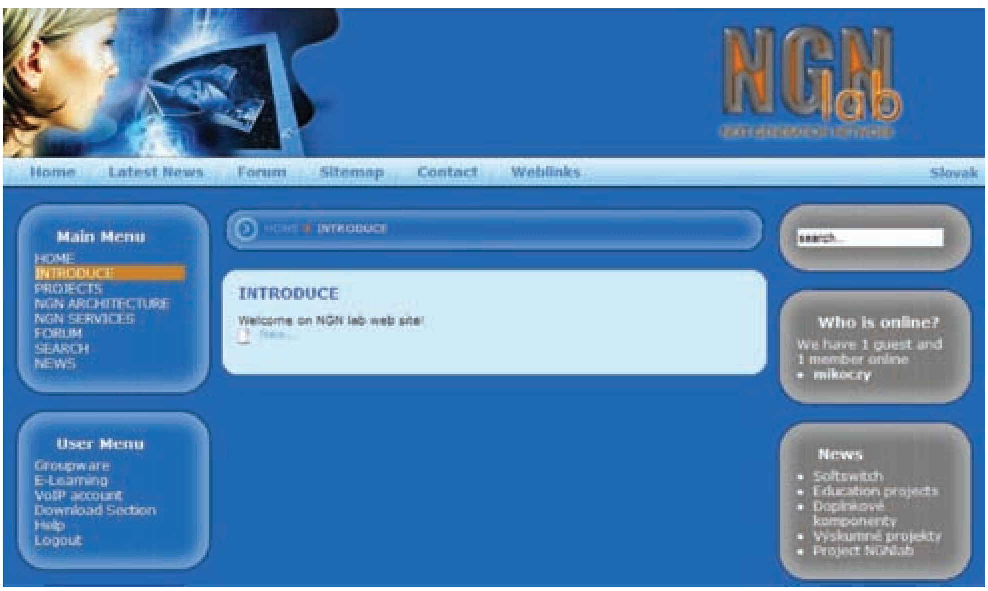

Figure 14. NGN Lab portal

7. Conclusion

This article deals with some aspects and processes of different types of networks convergence towards NGN. The conceptual model of the NGN architecture and possible migration scenarios are presented. The emphasis was given to convergence processes of the PSTN/IN and IP networks. As the case study, the proposed conception and configuration of the pilot NGN platform implemented at the STU Bratislava is described. This NGN platform and further outputs resulted from the research and development activities realized within the following projects:

1. State Research and Development Program "Building of the Information Society" granted by Slovak Ministry of Education:
   Projects:
   "Application of ICT Technologies and New Generation Network Platforms in Education",
   "Convergence of ICT networks and services in the Slovak communication infrastructure",
2. International educational project "Leonardo ICoTeL", granted by Leonardo da Vinci Programme,
3. National project – basic research "VEGA No. 1/3094/06", granted by Slovak Ministry of Education.

Abbreviations

3GPP – 3 Generation Partnership Project
FEs – Functional Entities
GPRS – General Packet Radio Service
ICT – Information and Communication Technologies
IMS – IP Multimedia Subsystem
IN – Intelligent Network
INAP – Intelligent Network Application Protocol
IP – Internet Protocol
NGN – Next Generation Network
PEs – Physical Entities
PSTN – Public Switched Telephone Network
QoS – Quality of Service
SIP – Session Initiation Protocol
VoIP – Vice over IP
UMTS – Universal Mobile Telecommunication System

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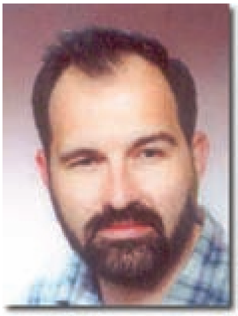

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Modeling of Tesla's Transmitter using the Antenna Theory Approach

Abstract

Modeling of Tesla's transmitter by using the wire antenna theory approach is presented in this work. The radiating part of the Tesla's transmitter is represented by an equivalent monopole antenna. This equivalent antenna is excited by an ideal current source replacing the Tesla's transformer. The frequency domain formulation is based on a homogeneous Pocklington integro-differential equation. Solving the Pocklington equation via the Galerkin Bubnov variant of the Indirect Boundary Element Method (GB-IBEM) the current distribution along the equivalent monopole antenna is obtained. Knowing the current distribution along the equivalent monopole antenna the radiated electric field is obtained by integrating the induced current along the wire. Numerical results for the antenna current and the related irradiated field is presented in the paper. This paper should be regarded as an opener to the subject, i.e. the first step towards the full wave model of the Tesla's transmitter.

Key words

Tesla’s transmitter, monopole antenna model, integral equation approach, boundary element method

1. Introduction

It is well known in the history of electrical science that Nikola Tesla unfortunately never finished his Long Island project and never put his transmitter in a full operation. Why? Tesla told us in his own words many years ago: *The practical success of an idea, irrespective of its inherent merit is dependent on the attitude of the contemporaries*. In spite of the fact that the invention of radio belongs to Nikola Tesla the majority of scientific community has never fully recognized his role. That was mainly due to the fact that Tesla had disputed Hertz's theory and had considered the radio waves produced by a Hertzian dipole as longitudinal shock waves in space, rather than transversal [1]. Nevertheless, his intriguing ideas and results still live on, even today, in almost every physicists or electrical engineer who has ever studied his work. Unfortunately, Tesla was never able to fully understand the gap between great ideas and the different processes to make them real and getting them to commercialization [2].

His remarkable idea was to develop a specific radio transmitter for a wireless transmission of not only communication signals, but also power at large distances. Consequently, Tesla has designed his magnifying transmitter described in [3], [4] by which he could efficiently emit Hertzian waves, or according to its own words, *currents through the earth* which was subjected to the device design [5], [6]. However, according to his strong belief Tesla considered transmission by the Hertzian waves as rather inefficient method compared to one on his own. Once, he compared Hertzian waves to his earth waves like cutting the butter with blunt instead with sharp edge of a knife. A trade-off between Hertzian wave and current wave can be found elsewhere, e.g. in [7]. If only Tesla had completed his Long Island transmitter station and put it in full operation, he would at least have had a fair chance to confirm his assumptions. We deeply believe that if Nikola Tesla had made it, we would have all lived in a different world, probably better.

In spite of a number of proofs that he had played an important essential role in the development of radio in its early phase Tesla's name was not among six radio pioneers selected by the European Broadcasting Union in 1996 [8].

Regardless of the fact that science of today considers Tesla's theory more or less fallacious [9], there have been many attempts not only to explain Tesla's work undertaken in Colorado Springs [10] and Long Island [11] and to explain his results, but also to follow on his work.

One of the most acceptable theories, according to the present state of the art, is the one that relays on coupling to the Schumann cavity [11].

It is noteworthy that the measurements results of cavity parameters (e.g. resonant frequencies, coherence time, etc.) obtained by Tesla are very close to the experimental results obtained much later. The experiments Tesla was up to perform were not carried out until the 1960s [13], when it was found that the Earth resonances at 8, 14 and 20 Hz [14]. Tesla's prediction was that the resonances would occur at 6, 18 and 30 Hz. Unfortunately, Tesla never presented full details how his "World System" would function [15]. What he provided were just some basic concepts and ideas on propagation mechanism.

Anyway, there are a fair number of reasons confirming a real necessity to continue the research on the subject.

A nice piece of work on Tesla's transmitter has been carried out by K. Corum and J. Corum [16], [17]. According to the model of slow-wave helical resonator transmission line [16] the magnifying effect is achieved by the standing waves in the secondary. In the same paper the transmission line (TL) mode T_0 is presented and standing wave formation explained. It is worth emphasizing that the very similar explanations can be also found in many Tesla's papers.

However, with the TL models with lumped source voltage it is not possible to predict standing wave pattern presented in [1]. Therefore, TL model proposed in [7], instead of a lumped voltage source at the bottom of the secondary, features a distributed voltage along the line and better describes the Tesla secondary. Some TL aspects of Tesla's propagation-through-Earth theory have been also discussed in [7].

This paper aims to analyze Tesla's transmitter by using the approach based on the wire antenna theory. According Tesla's idea his magnifying transmitter has been designed to not only efficiently emit non-Hertzian waves, but also to transmit power at large distances. Contrary to the use of mentioned *transmission line models*, this work analyzes the radiating part of Tesla's transmitter (secondary) via *monopole antenna model*. The formulation is based on the homogeneous Pocklington integro-differential equation.

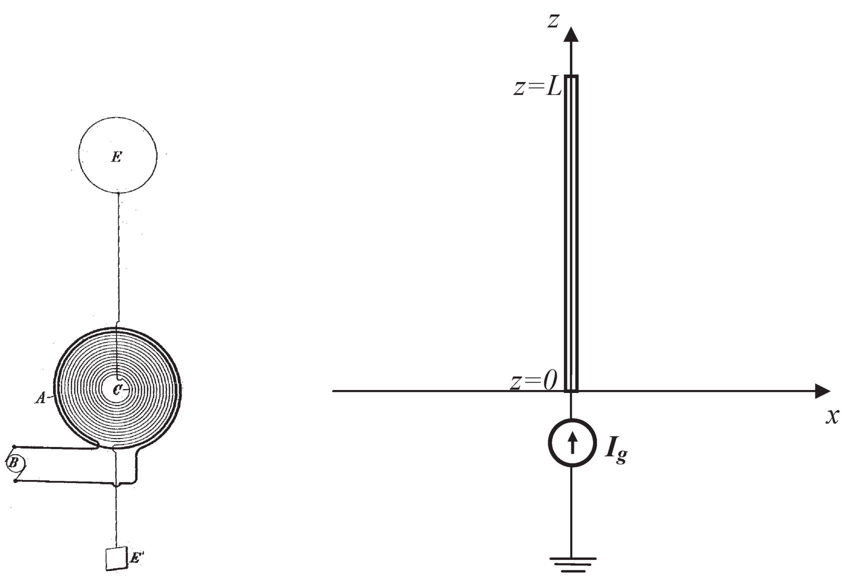
The Pocklington equation is numerically solved by means of the Galerkin Bubnov variant of the Indirect Boundary Element Method (GB-IBEM) and the current distribution along the equivalent monopole antenna is obtained, providing the field assessment.

2. Monopole Antenna Model: Integral Equation Formulation

Tesla's transmitter, shown in Fig 1a, is represented by an equivalent monopole antenna, shown in Fig 1b.

Therefore, the geometry of interest is related to a straight perfectly conducting (PEC) wire of length L and radius a, insulated in free space. The wire dimensions (L=65 m, a=10 cm) satisfy the well known thin wire approximation [18] so the current along the wire is assumed to be z-directed only.

The monopole antenna is excited by an ideal current source I_g, i.e. the antenna model of Tesla’s transmitter representing the current induced in the secondary input due to the oscillations in the primary.



a) Tesla's transmitter: electric scheme b) Equivalent monopole antenna

Figure 1. Monopole antenna representation of Tesla's Transmitter

A) Integral Equation for Current along the Wire

The key-point in the mathematical model is the assessment of the current distribution induced along the monopole antenna due to a time-harmonic excitation. This current is governed by the corresponding Pocklington integro-differential equation. The Pocklington equation can be derived by expressing the electric field in terms of the magnetic vector potential and by satisfying the boundary conditions for the tangential field components at the antenna surface.

The full electric field vector can be written, as follows:

$$\vec{E} = \frac{1}{j\omega\mu\varepsilon_0}\nabla(\nabla\vec{A}) - j\omega\vec{A} \tag{1}$$

where k is the phase constant of free space:

$$k^2 = \omega^2\mu_0\varepsilon_0 \tag{2}$$

while ε_0 and μ_0 denotes the permittivity and permeability of the free space.

Due to rotational symmetry the radiated electric field does not depend on azimuth variable Φ and the corresponding field components are given by:

$$E_\rho = \frac{1}{j\omega\mu\varepsilon_0}\frac{\partial^2 A_z}{\partial\rho\partial z} \tag{3}$$

$$E_z = \frac{1}{j\omega\mu\varepsilon_0}\frac{\partial^2 A_z}{\partial z^2} - j\omega A_z \tag{4}$$

The vector potential z-component is given by [15]:

$$A_z = \frac{\mu}{4\pi}\int_0^L g(x,z,z')I(z')\mathrm{d}z' \tag{5}$$

where $I(z')$ is the unknown current distribution along the vertical straight wire, $g(x,z,z')$ denotes the free space Green function of the form:

$$g(x,z,z') = \frac{e^{-jkR}}{R} \tag{6}$$

where R is the distance from the source point on the wire to the arbitrary observation point in free space, respectively.

The Pocklington integro-differential equation for the straight wire insulated in free space can be derived by enforcing the boundary conditions for the tangential electric field components on the perfectly conducting (PEC) wire surface. The total tangential electric field on the PEC wire surface ($\rho = a$) vanishes, i.e. the interface condition is given by:

$$E_z^{exc}(a,z) + E_z^{sct}(a,z) = 0 \tag{7}$$

where E_z^{exc} denotes the excitation function and E_z^{sct} is the related scattered field.

Combining the relations (4) to (7) yields the Pocklington integro-differential equation for the single wire in free space:

$$E_z^{exc} = -\frac{1}{j4\pi\omega\varepsilon_0}\int_0^L \left[\frac{\partial^2}{\partial z^2} + k^2\right] g_a(z,z')I(z')\mathrm{d}z' \tag{8}$$

where g_a is the integral equation kernel:

$$g_a(x,z,z') = \frac{e^{-jkR}}{R} \tag{9}$$

R_a is the distance from the source point on the wire to the arbitrary observation point in free space, respectively, given by:

$$R_a = \sqrt{(z-z')^2 + a^2} \tag{10}$$

In the analysis of Tesla's transmitter, the excitation function is not given in the form of electric field, as the equivalent antenna is neither illuminated by the plane wave, nor by the voltage generator. Thus, the left-hand side of the equation (8) vanishes and the integro-differential equation (8) becomes homogeneous:

$$-\frac{1}{j4\pi\omega\varepsilon_0}\int_0^L \left[\frac{\partial^2}{\partial z^2} + k^2\right] g_a(z,z')I(z')\mathrm{d}z' = 0 \tag{11}$$

The equivalent monopole antenna is excited by an ideal current generator with one terminal connected to the antenna and the other one grounded in the remote point in the space.

Therefore, the excitation is given in the form of the current flowing into the wire. This current source can be included into the integral equation scheme through the forced boundary condition applied at the top of the wire:

$$I(0) = I_g \tag{12}$$

where I_g denotes the actual current generator.

Integral equation (11) contains the quasisingular kernel due to the presence of differential operator [18]. This problem can be overcome by applying the so-called weak formulation of the problem and Galerkin Bubnov indirect Boundary Element Method (GB-IBEM).

Thus, utilizing the property of the integral equation kernel

$$\frac{\partial g_a(z,z')}{\partial z} = \frac{\partial g_a(z,z')}{\partial z'} \tag{13}$$

the alternative form of the integro-differential equation is obtained:

$$-\frac{1}{j4\pi\omega\varepsilon_0}\left[\int_{-L}^{L}\frac{\partial I(z')}{\partial z'}\frac{\partial g_a(z,z')}{\partial z}\mathrm{d}z' + k^2\int_{-L}^{L} I(z')g_a(z,z')\mathrm{d}z'\right] = 0 \tag{14}$$

The integrals in (14) contain quasisingular kernel due to the presence of differential operator.

Solving the Pocklington equation the antenna current is obtained.

B) Electric Field Formulas

The electromagnetic field radiated by the equivalent monopole antenna can be determined knowing the current distribution along the wire.

Inserting the expression for the magnetic vector potential (5) into equation (3) gives the radial (normal) field component:

$$E_\rho = \frac{1}{j4\pi\omega\varepsilon_0}\int_{-L}^{L} I(z')\frac{\partial^2 g(z,z',\rho)}{\partial\rho\partial z}\mathrm{d}z' \tag{15}$$

In addition, performing the integration by parts equation (15) becomes:

$$E_\rho = \frac{1}{j4\pi\omega\varepsilon_0} \int_{-L}^{L} \frac{\partial I(z')}{\partial z'} \frac{\partial g(z,z',\rho)}{\partial \rho} \mathrm{d}z' \tag{16}$$

The axial z-component of the electric field is defined by equation (4) and (5), i.e. by the following equation;

$$E_z = -\frac{1}{j4\pi\omega\varepsilon_0} \int_{-L}^{L} \left[\frac{\partial^2}{\partial z^2} + k^2 \right] g_0(z,z',\rho) I(z') \mathrm{d}z' \tag{17}$$

After integration by parts (17) becomes:

$$E_z = -\frac{1}{j4\pi\omega\varepsilon_0} \left[\int_{-L}^{L} \frac{\partial I(z')}{\partial z'} \frac{\partial g(z,z',\rho)}{\partial z} \mathrm{d}z' + k^2 \int_{-L}^{L} I(z') g(z,z',\rho) \mathrm{d}z' \right] \tag{18}$$

The integrals in expressions (16) to (18) contain quasi-singular kernel due to the presence of differential operator. This quasi-singularity can be efficiently treated by the boundary element/finite differences approach [19].

The model presented so far can be readily upgraded by taking into account the influence of the earth via the Sommerfeld integrals or via the Fresnel reflection coefficient [19].

3. Boundary Element Procedures

The Pocklington integro-differential equation (11) is numerically handled by means of the indirect Galerkin Bubnov Boundary Element Method [19]. The main steps of the method are outlined in this paper, for the sake of completeness. A more detailed description of the mathematical procedure can be found elsewhere, e.g. in [18] and [19].

The operator form of equation (11), can be symbolically written as:

$$K(I) = 0 \tag{19}$$

where K is a linear operator, I is the unknown current to be found for a given excitation E.

The unknown current is expressed by the sum of a finite number of linearly independent basis functions $\{f_i\}$ with unknown complex coefficients I_i, i.e.:

$$I \cong I_n = \sum_{i=1}^{n} I_i f_i \tag{20}$$

Applying the weighted residual approach and choosing the test functions to be the same as basis functions (Galerkin Bubnov procedure) the operator equation (19) transforms into a system of algebraic equations:

$$\sum_{i=1}^{n} I_i \int_0^L K(f_i) f_j \mathrm{d}z = 0 \qquad j = 1,2,\ldots,n \tag{21}$$

Performing certain mathematical manipulations the following matrix equation is obtained:

$$\sum_{i=1} [Z]_{ji} \{I\}_i = 0 \qquad j = 1,2,\ldots,M \tag{22}$$

where the vector $\{I\}$ contains the unknown coefficients.

The mutual impedance matrix $[Z]_{ji}$ represents the interaction of the i-th source boundary element with the j-th observation boundary element:

$$[Z]_{ji} = -\frac{1}{j4\pi\omega\varepsilon}\left(\int_{z_j}^{z_{j+1}} \{D\}_j \int_{z_i}^{z_{i+1}} \{D\}_i^T g_a(z,z')\mathrm{d}z'\mathrm{d}z + \right.$$
$$\left. +k^2 \int_{z_j}^{z_{j+1}} \{f\}_j \int_{z_i}^{z_{i+1}} \{f\}_i^T g_a(z,z')\mathrm{d}z'\mathrm{d}z \right) \tag{23}$$

Matrices $\{f\}$ and $\{f'\}$ contain the shape functions while $\{D\}$ and $\{D'\}$ contain their derivatives, where: M is the total number of segments, and z_i, z_{i+1}, z_j and z_{j+1} are the coordinates of i-th and j-th wire segment, respectively.

Once the numerical results for the current distribution along the antenna have been obtained the radiated electric field can be determined.

The electric field components can be calculated applying the boundary element/finite difference procedure to equation (16) in order to avoid the problem of the quasi-singularity of the Green function, (See Appendix). Thus, the radial field component is given by:

$$E_\rho = \frac{1}{j4\pi\omega\varepsilon_0}\sum_{i=1}^{M}\frac{I_{i+1}-I_i}{\Delta\rho\Delta z}\int_{z_i}^{z_{i+1}}[g(z,z',\rho+\Delta\rho/2)-g(z,z',\rho-\Delta\rho/2)]\mathrm{d}z' \quad (24)$$

where $\Delta\rho$ is the finite difference step.

The axial field component defined by equation (18) now can be written as (See Appendix):

$$E_z = -\frac{1}{j4\pi\omega\varepsilon_0}\sum_{i=1}^{M}\frac{I_{i+i}-I_i}{\Delta z}\left\{\begin{matrix}\int_{-L}^{L}[G(z+\Delta z/2,z',\rho)-G(z-\Delta z/2,z',\rho)]\mathrm{d}z'+ \\ +k^2\int_{-L}^{L}I(z')G(z,z',\rho)\mathrm{d}z'\end{matrix}\right\} \quad (25)$$

The integrals in expressions (24) and (25) are numerically evaluated using the Gaussian quadrature [19].

4. Computational Example

The electromagnetic radiation from the equivalent monopole antenna representing the Telsa's transmitter is analyzed for the operating frequency f=150 kHz. The antenna is energized by the unit current excitation, i.e.:

$$I_g = 1e^{j0} \quad (26)$$

Figure 2 shows the spatial current distribution along the equivalent monopole antenna, while the related tangential electric field component radiated by the monopole is shown in Fig 3. The antenna current shows linear behavior and falls to zero at the wire end satisfying the edge condition proposed by the thin wire approximation [18].

In addition, Fig 3 clearly demonstrates a rapid decay of the z-component of the electric field, important for the antenna radiation, with distance.

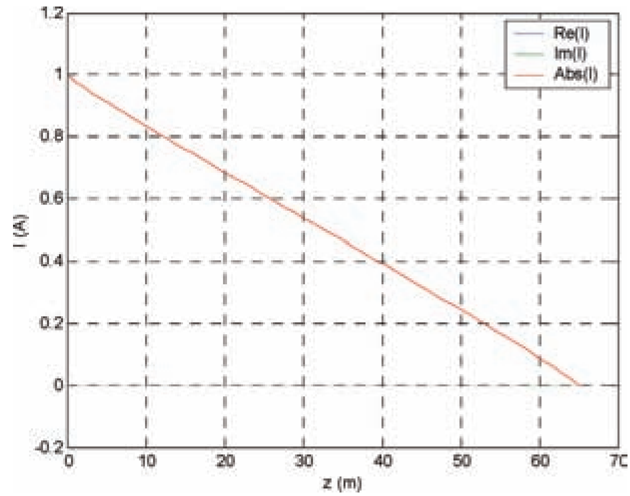


Figure 2. Current distribution induced along the equivalent monopole

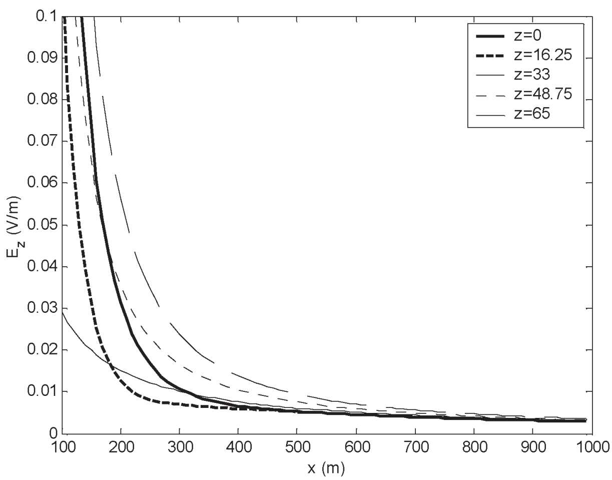


Figure 3. Electric field at different heights

This fact leads us to the conclusion that no significant (Hertzian) radiation occurs in the Tesla's transmitting system, i.e. no significant amount of electromagnetic energy is emitted from the structure into the free space.

A very similar conclusion has been drawn in [6] using the TL model, as well. The lateral view of the total radiated electric field is presented in Fig 4.

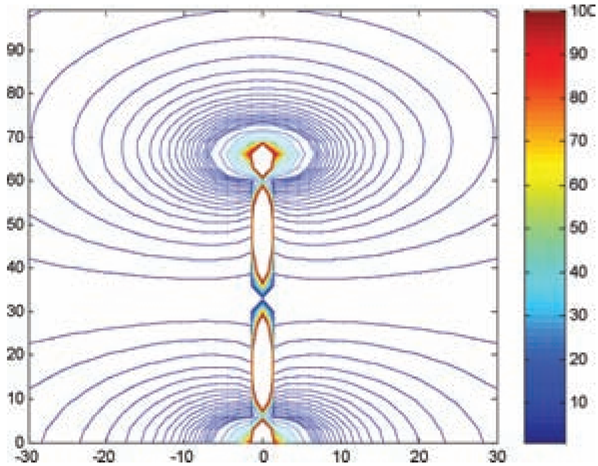


Figure 4. Radiated field around the monopole: lateral view

Obviously, having designed his transmitter a propagation mechanism different from Hertzian one was considered by Tesla.

5. Conclusion

By the very beginning of 20^{th} century Nikola Tesla strongly believed he was heading to the development of communication and power wireless transmission using his "World System". He never managed to ensure the financial support to work that out, and in spite of a number of proofs that he had made a significant contribution to the development of radio in its early phase Tesla's name did not appear among six radio pioneers selected by the European Broadcasting Union in 1996.

However, the spirit of his ideas still lives on and gives fuel to many researchers of today. In this work an antenna model of the Tesla's transmitter has been presented. The radiating part of the Tesla's transmitter has been represented by an equivalent monopole antenna excited by the ideal current source replacing the Tesla's transformer. The theoretical background is based on the frequency domain homogeneous Pocklington integro-differential equation. Solving the Pocklington equation numerically by using the Galerkin Bubnov variant of the Indirect Boundary Element Method (GB-IBEM) current distribution along the equivalent monopole antenna is obtained. Knowing the current distribution along the monopole antenna the radiated electric field is computed by integrating the induced current along the wire. Analyzing the calculated numerical results for the antenna current and related field it can be concluded that no significant (Hertzian) radiation occurs in the Tesla's transmitting system, i.e. no significant amount of electromagnetic energy is emitted from the structure into the free space. This fact fosters the assumption that Tesla considered some different propagation mechanism while having designed his transmitter. This work should be regarded as an opener to the subject, i.e. the first step in the full wave model of the Tesla's transmitter, while the ongoing work deals with the inclusion of earth effects via the Sommerfeld integral approach or the Fresnel reflection coefficient.

Appendix: Evaluation of the Field Integrals

The radial field component, defined by the integral:

$$E_\rho = \frac{1}{j4\pi\omega\varepsilon_0} \int_{-L}^{L} \frac{\partial I(z')}{\partial z'} \frac{\partial g(z,z',\rho)}{\partial \rho} \mathrm{d}z' \tag{A1}$$

can be computed numerically using Gaussian quadrature.

The approximation for current along the segment can be written as:

$$I(z) = I_i f_i(z) + I_{i+1} f_{i+1}(z) \tag{A2}$$

Thus the shape functions are given by:

$$f_i(z) = \frac{z_{i+1} - z}{\Delta z} \qquad f_{i+1}(z) = \frac{z - z_i}{\Delta z} \tag{A3}$$

Therefore it follows:

$$\left.\frac{\partial I(z')}{\partial z}\right|_{z=z_i} = \frac{I_{i+1} - I_i}{\Delta z} \tag{A4}$$

and:

$$E_x = \frac{1}{j4\pi\omega\varepsilon_0} \sum_{i=1}^{M} \frac{I_{i+1} - I_i}{\Delta z} \int_{z_i}^{z_{i+1}} \frac{\partial g(z,z',\rho)}{\partial x} \mathrm{d}z' \tag{A5}$$

Furthermore, the kernel can be approximated via central finite difference formula:

$$\frac{\partial f(x,y)}{\partial x} = \frac{f(x+\Delta x,y)-f(x-\Delta x,y)}{2\Delta x} \tag{A6}$$

And the final formula for the radial electric field is then:

$$E_\rho = \frac{1}{j4\pi\omega\varepsilon_0}\sum_{i=1}^{M}\frac{I_{i+1}-I_i}{\Delta\rho\Delta z}\int_{z_i}^{z_{i+1}}[G(z,z',\rho+\Delta\rho)-G(z,z',\rho)]\mathrm{d}z' \tag{A7}$$

where $\Delta\rho$ denotes the finite difference step.

Similarly, the axial field component is given by:

$$E_z = -\frac{1}{j4\pi\omega\varepsilon_0}\left[\int_{-L}^{L}\frac{\partial I(z')}{\partial z'}\frac{\partial G(z,z',\rho)}{\partial z}\mathrm{d}z' + k^2\int_{-L}^{L} I(z')G(z,z',\rho)\mathrm{d}z'\right] \tag{A8}$$

Using linear interpolation for current over the segment it follows:

$$E_z = -\frac{1}{j4\pi\omega\varepsilon_0}\sum_{i=1}^{M}\left\{\begin{array}{l}\dfrac{I_{i+i}-I_i}{\Delta z}\displaystyle\int_{-L}^{L}\frac{\partial G(z,z',\rho)}{\partial z}\mathrm{d}z' + \\ +k^2\displaystyle\int_{-L}^{L}[I_i f_i(z')+I_{i+1}f_{i+1}(z')]\,G(z,z',\rho)\mathrm{d}z'\end{array}\right\} \tag{A9}$$

and approximating the kernel with finite differences the final formula for the axial field component is given by:

$$E_z = -\frac{1}{j4\pi\omega\varepsilon_0}\sum_{i=1}^{M}\frac{I_{i+i}-I_i}{\Delta z^2}\left\{\begin{array}{l}\displaystyle\int_{-L}^{L}[G(z+\Delta z/2,z',\rho)-G(z-\Delta z/2,z',\rho)]\mathrm{d}z' + \\ +k^2\displaystyle\int_{-L}^{L} I(z')G(z,z',\rho)\mathrm{d}z'\end{array}\right\} \tag{A10}$$

A linear approximation over each boundary element has been used in this paper as this choice had already been shown to provide accurate and stable results [19].

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Application of Advanced Encryption Standard in Virtual Private Networks Implementation

Abstract

The Point-to-Point protocol provides a standard method for transporting multi-protocol datagram's over point-to-point links. In this paper we consider an implementation of Advanced Encryption Standard with Authentication and Encryption protocols in order to make secure PPP connections. This paper gives practical protocols that implement it. The proposed solution makes secure PPP connections as Advanced Encryption Standard as itself. The proposed schemes have different properties as to implementation and security and have been testified through practical realizations in Borland C++ and MS C#.NET programming languages.

Key words

Algorithm, authentication, encryption, decryption, protocol

1. Introduction

Virtual Private Network (VPN) is a technology that provides extension of private network over the public and other private networks. Virtual means – because it depends on the use of virtual connections – that is, temporary connections that have no real physical presence, but consist of packets routed over various machines on the Internet on an ad hoc basis, and private means – the confidentiality, integrity and authenticity of data and information must be guaranteed at all times although we use unsecure public networks (as the Intranet). VPN is a concept that blurs the line between a public and private network.

VPN can make use of the public telecommunications structure, thereby reducing costs compared to the use of leased lines or frame relay connections.

Modern organisational structures call for close contact between foreign ministries, embassies and diplomats right around the world. Tactically-relevant information has to be transmitted at short notice from headquarters into the field. E-commerce financial transactions demand secure information paths. The use of VPNs is advisable in cases where different sites or external personnel have to be linked. VPNs can also be used to link up two sites within the same organization (instead of dedicated lines).

But it's not all perfect. Virtual networks are not without their drawbacks. During data exchange over the Internet, data may unavoidably pass through various unknown sub-networks. However, this type of data transmission is unacceptable for sensitive in-house data unless security precautions are put in place. The security elements used to protect the information must satisfy the preconditions for confidentiality, integrity and authenticity. Authentication and authorization mechanisms must be selected that restrict access to duly authorized users only. Consequently, the entire data communication within the private or public network must be encrypted. This is the only way of ensuring that the transmitted data remains confidential and protected.

Communication via the Internet, as well as via any communication network, should only take place via authenticated, fully encrypted channels.

There are several VPN solutions based on the encryption. The most frequently used solutions are: Point-to-Point Challenge Handshake Authentication Protocol (PPP CHAP) [1], Point-to-Point Encryption Control Protocol (PPP ECP) [2], encryption protocol based on the Data Encryption Standard (PPP DESE) [3], Microsoft Challenge Handshake Authentication Protocol (MS CHAP) [4] [5], Microsoft Encryption Protocol (MS EP) [6], and Layer Two Tunneling Protocol (L2TP) [7] based on the Internet Security Protocol (IPSec). These solutions show weaknesses in both encryption algorithms and their implementation.

Cryptanalysis of Microsoft's solutions [8] shows that these solutions have unacceptable weaknesses.

2. VPN techniques

There are several technologies that VPNs use to protect data traveling across public networks (e.g. the Internet). The most important concepts are firewalls, authentication, encryption, and tunneling.

Many VPN solutions use tunneling to create a private network.

Tunneling allows you to encapsulate a packet within a packet to accommodate incompatible protocols. The packet within the packet could be of the same protocol or of a completely foreign one. With tunneling you can also encapsulate an IP packet within another IP packet. This means you can also send packet with arbitrary source and destination addresses across the Internet within a packet that has Internet-routable source and destination addresses. The practical upshot of this is that you can use the reserved (not Internet-routable) IP address space set aside by the Internet Assigned Numbers Authority (IANA) for private networks on your LAN, and still access your hosts across the Internet. The benefit of IP encapsulation is that it allows many different protocols to be routed across an IP medium, such as the Internet. There are small numbers of point-to-point IP links. Reason for that is the lack of a standard encapsulation protocol. There are plenty of non-standard encapsulation protocols available, but there is not any which has been agreed upon as an Internet Standard. By contrast, standard encapsulation scheme do exist for the transmission of datagram's over most popular LANs.

Point-to-Point Protocol (PPP) [9] provides an encapsulation protocol over both bit-orientated synchronous links and asynchronous links with 8 bits of data and no parity. These links must be full-duplex, but may be either dedicated or circuit-switched.

Authentication techniques are essential to VPNs, as they ensure the communicating parties that exchange data with the correct user or host.

Encryption can be regarded as method for altering data into a form that is unusable by anyone else except the intended recipient, who has the means necessary to decrypt it.

VPNs, however, need to encrypt data in real time, rather than storing the data as file.

3. Advanced encryption standard

3.1. Design basic

Advanced Encryption Standard (AES), also known as Rijndael [10] is an iterated block cipher with a variable block length and a variable key length. The block length and the key length can be independently specified to 128, 192 or 256 bits.

Several operations in Rijndael are defined at byte level, with bytes representing elements in the finite field $GF(2^8)$. Other operations are defined in terms of 4-byte words. The elements of a finite field can be represented in several different ways. For Rijndael the classical polynomial form presentation has been chosen.

In the polynomial presentation, the sum of two elements is the polynomial with coefficients that are given by the sum modal 2 of the coefficients of the two terms. All necessary conditions are fulfilled to have an Abelian group. Very element is its own additive inverse. As every element is its own additive inverse, subtraction and addition are the same.

In the polynomial presentation, multiplication in $GF(2^8)$ corresponds with multiplication of polynomials modal an irreducible binary polynomial of degree 8. For Rijndael, this polynomial is called $m(x)$ and given by

$$m(x) = x^8 + x^4 + x^3 + x + 1$$

or '11B' in hexadecimal presentation.

Polynomials can be defined with coefficients in $GF(2^8)$. In this way, a 4-byte vector corresponds with a polynomial of degree below 4.

Polynomials can be added by simply adding the corresponding coefficients. As the addition in $GF(2^8)$ is the bitwise XOR, the addition of two vectors is a simple bitwise XOR.

Multiplication is more complicated. Assume we have two polynomials over $GF(2^8)$: $a(x)$ and $b(x)$. Their product $c(x) = a(x)b(x)$ can no longer be represented by a-byte vector. By reducing $c(x)$ modulo a polynomial of degree 4, the result can be reduced to a polynomial of degree below 4. In Rijndael, this is done with the polynomial $M(x) = x^4 + 1$.

In most ciphers, the round transformation has the Feistel Structure. In this Structure typically part of the bits of the intermediate State are simply transposed unchanged to another position. The round transformation of Rijndael does not have the Feistel Structure. The round transformation is composed of tree distinct invertible uniform transformations, called layers. The specific choices for different layers are to provide resistance aging linear and differential cryptanalysis. Every layer has its own function:

a) The linear mixing layer – guarantees high diffusion over multiple rounds.
b) The non-linear layer – parallel application of S-boxes that have optimal worst-case nonlinearity properties.
c) The key addition layer – A simple XOR of the Round Key to the intermediate State.

3.2. Expected Strength

Rijndael is expected, for all key and lengths defined, to have as good as can be expected from a block cipher with the given block and key lengths.

This implies, among other things, that most efficient key-recovery attack for Rijndael is exhaustive key search. Obtaining information from given plaintext-ciphertext pairs other plaintext-ciphertext pairs cannot be done more efficiently than by determining the key by exhaustive key search. The expected effort of exhaustive key search depends on the length of the Cipher Key and is:

a) for 16-byte key, 2^{127} applications of Rijndael,
b) for 24-byte key, 2^{191} applications of Rijndael,
c) for 16-byte key, 2^{255} applications of Rijndael.

The reason for this is that a considerable safety margin is taken with respect to all known attacks.

3.3. Security goals

In order to formulate security goals, some security-related concepts need to be defined.

A block cipher, with block length v, has $V = 2^v$ possible inputs. If the key length is u it defines a set of $U = 2^u$ permutations over $\{0,1\}^v$. The number of possible permutations over $\{0,1\}^v$ is $V!$. Hence the number of all possible block ciphers of dimensions u and v is $((2^v)!)^{(2^u)}$ or equivalently $(V!)^U$.

Definition: A block cipher is *K*-secure if all posible attack strategies for it have the same expected work factor and storage requirements as for the majority of possible block ciphers with the same dimensions. This must be case for all possible modes of access for the adversary (known / chosen / adaptively chosen plaintext / ciphertext, known / chosen / adaptively chosen key relations...) and for any a prior key distribution [10].

K-security is a very strong notion of security. It can easily be concluded that if one of the following weaknesses apply to a cipher, it cannot be called *K*-secure:

a) Existence of key-recovering attacks faster than exhaustive search,
b) Certain symmetric properties in the mapping,
c) Occurrence of non-negligible classes of weak (as in IDEA),
d) Related-key attacks.

K-security is a relative measure. It is possible to build a *K*-secure block cipher with a 5-bit block and key length, but it has small dimensions.

It is possible to imagine ciphers that have certain weaknesses and still are *K*-secure. For these there is another security concept, deoted by term hermetic.

Definition: A block cipher is hermetic if it does not have weaknesses that are not present for the majority of block ciphers with the same block and key length [10].

For the Rijndael the security goal is: the Rijndael is *K*-secure ande hermetic.

4. Application of advanced encryption standards with PPP

In order to create the VPN, Rijndael is very feasible for Point-to-Point links implementation. This algorithm can be used very efficiently with respect to authentication, encryption and generation of keys.

This document describes Rijandael functioning with regard to Point-to-point links and VPN creation based on secret keys infrastructure, whenever the algorithm is used in schematics requiring encryption.

4.1. Encrypted Password (Password Hash)

Encrypted password is shared secret information (Password Hash). There are no limitations with regard to password length. Passwords with less than 32 characters are adequately expanded to the value of 32 characters. Password Hash is obtained by encrypting the expanded password using Rijndael block cipher and the System key.

System key is character string with length of 32 (256 bits). In order to avoid Dictionary attack, 256 bit string random variable can be used instead of password.

4.2. PPP RCHAP (Rijndael Challenge Handshake Authentication Protocol)

In this chapter Rijndael algorithm is recommended for user authentication before the NLP (Network Layer Protocol) transmission is allowed on the link. The assumption is that the algorithm identification number is assigned by IANU and with the value of $0 \times aa$.

4.2.1. RCHAP Protocol Basic Features

RCHAP is used for periodical verification of the identity of the peer using 4-way handshake. This is done upon initial link establishment, and may be repeated anytime after the link has been established. The procedure is as follows:

1. After the link establishment phase is completed, the authenticator sends ''challenge'' message to the client.
2. Client responds with a calculated response and his ''challenge''.
3. The authenticator checks the response against its own calculation of the expected value. If the values match, the authentication is acknowledged, and than he sends a success packet including authenticator's response on client's ''challenge''. Otherwise, he sends failure packet and terminates the link.

4. Client checks the authenticator's response. If the values match, the authentication is acknowledged than he sends a success packet, otherwise the failure packet is sent instead, and the link is terminated.

4.2.1.1. Configuration Option Format

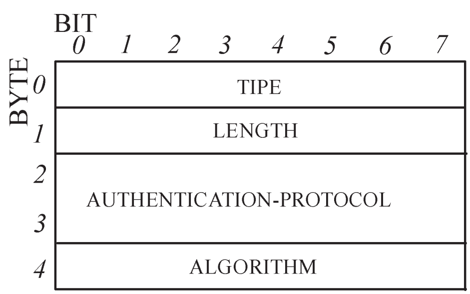

Figure 1. Authentication-Protocol Configuration Option format to negotiate RCHAP

RCHAP is enabled by negotiate CHAP algorithm 0×*aa* in LCP (Link Control Protocol) option 3. A summary of the Authentication-Protocol Configuration Option format to negotiate RCHAP is shown on figure 1. The fields are transmitted from the top to down.

Value of the fields is: type 3, length 5, authentication-protocol 0×*c*223, and algorithm 0×*aa*.

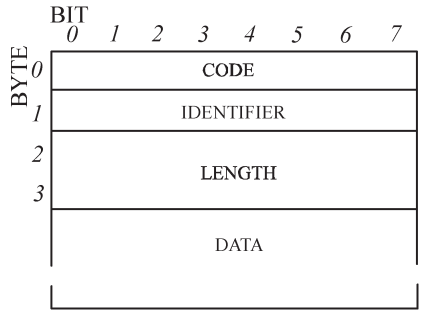

Figure 2. RCHAP packet format

4.2.1.2. Packet Format

Exactly one RCHAP packet is encapsulated in the Information field of PPP Data Link Layer frame. A summary of the RCHAP packet format is shown on figure 2. The fields are transmitted from the top to down.

The Code field has the length of one byte and identifies the type of RCHAP packet. RCHAP Codes are assigned as follows:

1 Challenge
2 Response
3 Success server packet
4 Success client packet
5 Failure
6 Change Password packet

The Identifier field is one byte and aids in matching challenges, responses and replies.

The Length field is two bytes and identikits the length of RCHAP packet including the Code, Identifier, Length and Data fields.. Bytes outside the range of the Length field should be treated as Data Link Layer padding and should be ignored on reception.

The Data field is zero or more bytes. The format of Data field is determined by the Code field.

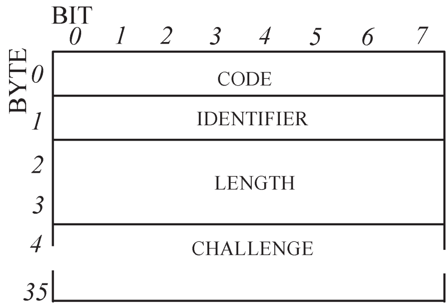

Figure 3. RCHAP Challenge packet format

4.2.1.3. Challenge Packet

The Challenge packet is used to begin the RCHAP. The authenticator must transmit a RCHAP packet with Code field set to 1 (Challenge). Additional Challenge packet must be sent until a valid Response packet is received, or an optional retry counter expires. A Challenge packet may also be transmitted at any time during the NLP phase to ensure that the connection has not been altered. The client should expect Challenge packets during the Authentication phase and NLP phase. Whenever a Challenge packet is received, the client must transmit a RCHAP packet with the Code field set to 2 (Response). A summary of the Challenge packet is shown on figure 3. The fields are transmitted from the top to down.

The Code field is 1. The Identification field is one byte. The Identifier field must be changed each time a Challenge is sent.

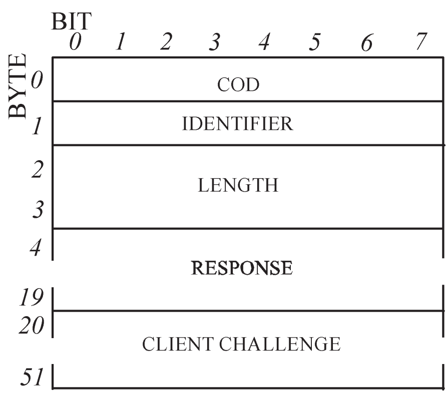

Figure 4. Response RCHAP packet format

The Challenge is 32 bytes. Value of this field is altered for every Challenge RCHAP packet. Challenge value should be generated as random as possible. One of the good methods of generating such value is to encrypt 256 bits of any pseudorandom byte generator, using Rijndael cipher. Generator of pseudorandom bytes can also be realized by the Rijndael cipher. [10].

4.2.1.4. Response Packet

Whenever a Challenge packet is received, the client must transmit a RCHAP packet with the Code field set to 2 (Response). Response RCHAP packet also contains Challenge for server in order to server authentication. A summary of the Response RCHAP packet is shown on figure 4. The fields are transmitted from the top to down.

The Code field is 2. The value of identification field is copied from Challenge RCHAP packet that caused the Response RCHAP packet. Length of Response field is 16 bytes. Response value is calculated as follows:

1. 256 bit cipher key is generated by encrypting the Challenge value with 256 bit Password Hash value.
2. 256 bit block of Password Hash value is divided on two 128 bit blocks.
3. First block from step (2) gets encrypted using Rijndael cipher (block length is 128 bits, cipher key length is 256 bits) with cipher key generated in step (1). Second block from step (2) is previously EXOR-ed with first encrypted block and than encrypted using the cipher key from the step (1). Resulting 128 bit block of second encryption procedure is the Response value.

Value of the Client Challenge field serves for server identification in order to ensure that other, server side of communication is authentic, as well. This field value is generated in the same way as server's Challenge value.

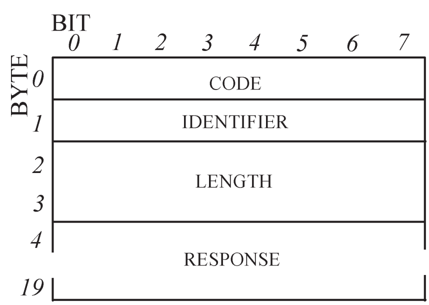

Figure 5. Success Server RCHAP packet format

4.2.1.5. Success Server Packet

Whenever a Response packet is received, the authenticator compares the Response Value with its own calculation of the expected value. Based on this comparison, the authenticator must send a Success Server packet. Since this package might be lost, server must allow repetition of Response packet during NLP phase. A summary of the Success Server packet is

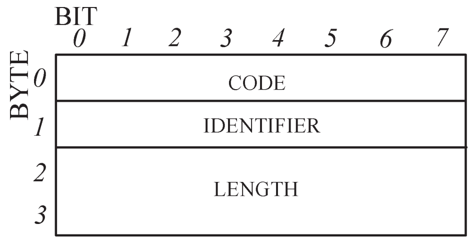

Figure 6. Success Client RCHAP packet format

shown on figure 5. The fields are transmitted from the top to down.

The Code field is 3. The Identification field is copied from Response RCHAP packet which caused this Success Server RCHAP packet. The Response field length is 16 bytes, and its value is calculated identically as value of the Client Response.

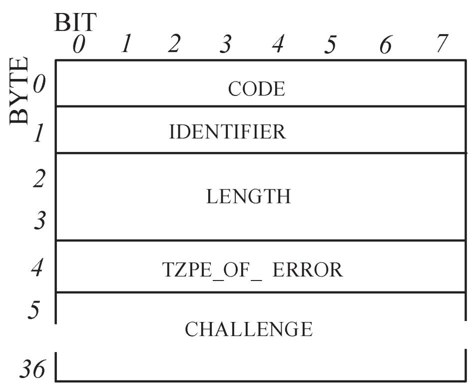

Figure 7. Failure RCHAP packet format

4.2.1.6. Success Client Packet

Whenever a Success Server packet is received, the client compares the Response with its own calculation of the expected value. Based on this comparison, the client must send a Success Client packet with Code field set on 4. A summary of the Success Client packet is shown on figure 6. The fields are transmitted from the top to down.

The Code field is 4. The Identification field is copied from Success Server package that caused the RCHAP packet.

4.2.1.7. Failure Packet

If expected and received Response values are not identical, the client and the server must return RCHAP package with Code field set on 5 (Failure Packet). A summary of the Failure Packet is shown on figure 7. The fields are transmitted from the top to down.

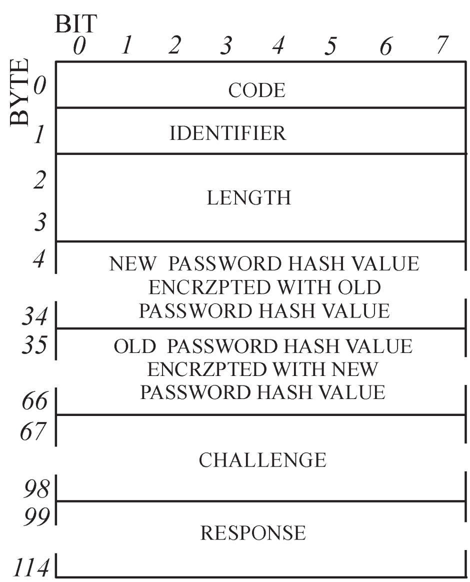

Figure 8. Change Password RCHAP packet format

The Code field is 5. Value of identification field is a value of identification field causing this RCHAP packet. Type of Error Field is one byte length and specifies the reasons resulting with this packet. Values of the field are as follows:

1. ERROR_AUTENTICATION_FAILURE
2. ERROR_NO_DIALIN_PERMISSION
3. ERROR_PASSWORD_EXPIRIED
4. ERROR_CHANGING_PASSWORD

The Challenge field length is 16 bytes and its value is generated as described above.

4.2.1.8. Password Packet Change

This RCHAP package is sent only if authenticator reports: ERROR_PASSWORD_EXPIRIED message. A summary of the Change Password Packet is shown on figure 8. The fields are transmitted from the top to down.

The Code field is 6. Value of identification field is a value of identification field causing this RCHAP package.

Value of the New Password Has Value Encrypted with Old Password Hash Value is obtained by encrypting New Password Hash Value using Old Password Hash Values as cipher key.

Value of the Old Password Hash Value Encrypted with New Password Hash Value is obtained by encrypting the Old Password Hash Value using the New Password Hash Values as cipher key.

4.3. PPP REP (Rijndael Encryption Protocol)

ECP protocol provides methods for negotiation and usage of encryption protocols using PPP encapsulated links.

This part describes specifications of using Rijndael encryption algorithm for encryption of PPP encapsulated packets. Although Rijndael provides multiple operation modes, we will describe usage of ECB (Electronic Code Book) and CBC (Cipher Block Chaining) modes whereby all block and key lengths are possible. Change of cipher key is done for each packet.

4.3.1. REP ECP Configuration Option

The assumption is that link encryption is not required. However, if the link encryption is under negotiations and negotiations fail than the link is going to be terminated. Negotiations on encryption use take place

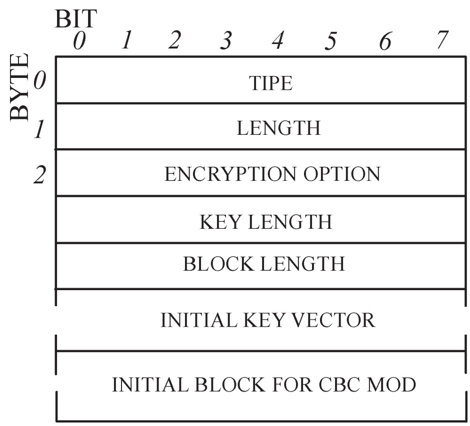

Figure 9. REP ECP Configuration Option packet format

when link reaches NCP (Network Control Protocol) phase. ECP packets received before the NCP phase is reached should be rejected. ECP uses (decimal) codes from 1 to 7 (Configure-Request, Configure-Ack, Configure-Nak, Configure-Reject, Terminate-Request, Terminate-Ack and Code-Reject, including the code 14 (Reset-Request) and code 15 (Reset-Ack). Remaining codes should be treated as unrecognizable and result with Code-Reject.

REP ECP configuration option shows that Rijndael algorithm is offered for link decryption and technically it represents a request to a peer for packet encryption. This configuration option has two versions. First one is to request from IANU an assignment of separate identification protocol number (0×8053 i.e. 0×8055) specifying application of concrete manufacturer. The second one is to use standard ECP where the Configuration Request field will have the 0 value which will provide OUI negotiation mechanism without requesting from IANA assignment of optional number. OUI field in Configuration Request should have the value of first three bytes Ethernet addresses of application manufacturers are assigned by the IEEE 802. Further down, first version will be described. Assumed assigned value for Protocol field of ECP Configuration Option is $0 \times x0x0$.

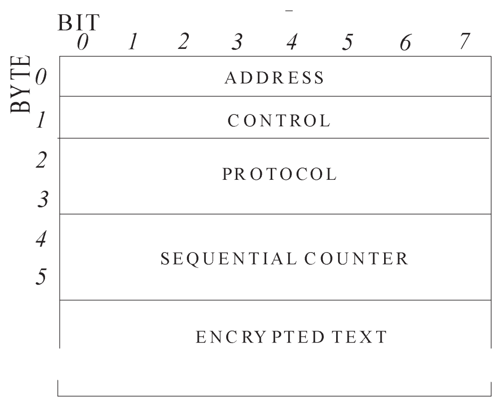

Figure 10. REP packet format

A summary of the REP ECP Configuration Option format is shown in figure 9. The fields are transmitted from the top to down.

The Type field is 0, and value of the Length field is 69. The Encryption Option Field is 0 for ECB mode, and 1 for CBC mode. Key Length is 1 for 128-bit key, 2 for 192-bit key and 3 for 256-bit key. Same method is used for the value of the Block length field.

Initial Key Vector field and Initial Block for CBC mode are 32 byte long and value is determined on similar way. One of the methods to assign these values is generating a Challenge as described before.

4.3.2. REP Packet Format

A summary of the REP Packet format is shown on figure 10. The fields are transmitted from the top to down.

Address and Control Fields must be included if the Configuration Option of compressing PPP Address and Control field are not negotiated. Value of the Protocol Field is $0{\times}00x0$ (assigned by IANU). Sequential counter is 16-bit number assigned by the encrypted and its value starts from zero and increments for each encrypted packet. The Encrypted Text field is output from encrypted.

4.3.3. Encryption

Before any encrypted packets my be communicated, PPP must reach the NLP phase, and the ECP must reach the opened state.

When REP ECP has reached phase opened, sender must not apply encryption on LCP and ECP packets. If Mapping of Control Characters on the asynchronous link Configuration Option has been negotiated, sender applies mapping after encryption.

4.3.3.1. Cipher text

The text packet is generated by iterative process:

$$C_i = E_{k_j}(P_i)\ (i = 1,2,3,\ldots)\ \text{for ECB mod,}$$

Where i is the index of block (b length) in j packet, and k_j is the cipher key in j packet,

$$C_i = E_{k_j}(P_i\hat{\ }C_{i-1})\ (i = 1,2,3,\ldots)\ \text{for CBC mod,}$$

Where i is the index of block (b length) in whole plaintext, and k_j is the cipher key in j packet. C_{i-1} is cipher text in $i-1$ block, where is $C_0 = E_{k_0}(P_0)$, (P_0 initial block received in REP ECP Configuration Option Packet).

4.3.3.2. Decrypted text

The decrypted text is generated by iterative process:

$$P_i = D_{k_j}(C_i)\ (i = 1,2,3,\ldots)\ \text{for ECB mod.}$$

Where the i is index of block (b length) in j packet and the k_j is cipher key in j packet,

$$P_i = C_{i-1}\hat{\ }D_{k_i}(C_{i-1})\ (i = 1,2,3,\ldots)\ \text{for CBC mod,}$$

Where the i is index of block (length b) in whole cipher text, and the k_j is cipher key in j packet. C_{i-1} is cipher text in $i-1$ block, where is $C_0 = E_{k_0}(P_0)$, (P_0 initial block received in REP ECP Configuration Option Packet).

4.3.3.3. Cipher key

The cipher key is changed for every block for both ECB and CBC mod. The cipher key is obtained by using the Password Hash value and Initial Key Vector.

Process of generating block cipher key is:

1. The Password Hash value *hp* is matched to key length.
2. The Master cipher key k_M is obtained by EXOR of Password Hash value and Initial Key Vector *vk*, ($k_M = hp \hat{} vk$).
3. The Cipher key k_0 is obtained by encrypting of Initial Key Vector *vk* with the Master cipher key k_M, ($k_0 = E_{k_M}(vk)$.
4. The Cipher key k_1 is obtained by encrypting EXOR value of *vk* and k_0 using k_M, ($k_1 = E_{k_M}(vk \hat{} k_0)$).
5. Next Cipher key k_i is obtined by iterativ process: $k_i = E_{k_M}(k_{i-2} \hat{} k_{i-1})$.

5. Conclusions

The proposal of usage the Rijndael with VPNs, does not have impact on the strength of the algorithm, which implies that, VPN based on the Rijndael has same security level as the Rindael itself.

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An Analytical Approach to Error Evaluation in Gamma Shadowed Nakagami-m Fading Channel for Different Path Loss Models

Abstract

In this paper, considering general model of radio channel, where receiving signal is submitted by accidental fluctuations of the amplitude and phase, well known as fading, the aspect of composite fading parameters impact on the probability of error for GMSK modulation format, has been discussed. Composite shadowed Nakagami-m fading channel model is used to describe the statistical properties of wireless channel since the signal propagation is affected by three statistically independent phenomena: deterministic path loss, slow lognormal shadowing and fast multipath fading. Different models used for estimation of path loss in wireless channel were treated. For resolving problems, we used the new analytically derived closed-form expressions for the amplitude distributions and probability density function in gamma shadowed and varying Nakagami-m fading channel, which considers alternative approximation based on gamma-contribution. While solving the problem mentioned above, the analytical solution based on relevant approximation has been used, having in mind that there isn't any exact analytical expression for the static error probability for noncoherent GMSK receiver.

Key words

Average error probability, composite fading, gamma pdf, multipath fading, noncoherent receiver.

1. Introduction

BASIC goal in this paper is to generate results that will provide explicit influence analysis of composite generalized (*Nakagami-m*) fast fading and lognormal slow fading on GMSK modulation form in mobile link channel. As a result, more simple and concise analysis or/and system optimization during fading parameters variation is expected. Obviously, a valid result for transmission quality measurement in mobile link channel, must contain parameters which characterize all three components of accidential amplitude variations in recieved signal (*path loss*, *multipath fading*, *shadowing)*. In papers [1]-[3], [15] *pdf* (*probability density function*) expressions have been obtained for composite anvelope of fast – Rayleigh and slow – lognormal fading, and next, *pdf* gained in that way is used to calculate average error probability. In analysis, according to that scenario, analytical problem is encourted already during first step. In fact, responding *pdf* has integral form, meaning all following operations over this *pdf* are possible to execute only by following the method of multiple numerical integrations. In further papers, in order to minimize described analytical problems, composite *pdf* in Rayleigh fading and lognormal slow fading is aproximated using equivalent lognormal *pdf* [13], while in [4]-[5] composite *pdf* in Rayleigh and slow fading is aproximated with *K*-distribution. In [16] gamma *pdf* is proposed, as a statistical model of slow fading, and for statistical model for the fast fading, Nakagami fading is used. This statistic model for amplitude fluctuations will later be refered to as composite fading. Aplying momentum method in [17] coditions are established, and according to these conditions gamma *pdf* represents adequate aproximation for lognormal *pdf*. Based on composite fading anvelope statistic tool [6] is generated, and it is applied for calculation of average error probability in different noncoherent modulations as well as for calculating probability of outage in channel with cochannel interference as dominant interference. Also in this paper, adequate analysis of outage probability is conducted, which indicated some analytical irregularityes in [6]. So, new results which describe interference influence on the mobile channel link quality are gained.

Symbol error probability expression for noncoherent reciever of GMSK signal in channel with presence of AWGN (static, conditional) is conducted following aproximation of experimentaly gained curves [7]. Further, averaging static error probability according to statistics of composite fading, expressions for error probability in channel with composite fading are gained. Application of MGF (*moment generating function*) method [12] was very usefull in case of coherent recieving of MPSK, MQAM i MDPSK modulation format [8].

This shows eficiency of MGF method even in the case of noncoherent recieving of GMSK signal, because expressions gained are responding to the results in [7].

2. Forming analytical tool

In this research channel is lowdispersive , (nonselective fading) whose appearance coditions are: $\frac{L}{T_s} << 1$ and $F_d \cdot T_s << 1$, where L i F_d are characteristics of time dispersity and frequency dispersity for the channel observed respectively.

Accidential amplitude fluctuations can be presented as three components [12], [13]:

1. Slow changes in average signal strength in function of distance between transmitter and reciever (according to power function law or some more complex empirical or theoretical law).
2. Slow accidental fluctuations in recieving signal average power – slow fading, *shadowing* (according to general concensus these fluctuations follow lognormal distribution).
3. fast fluctuations around instantaneous average value – fast *multipath* fading. Statistics of these fluctuations can be Rayleigh, Rice, or in general Nakagami.

In general, anvelope μ, of fast fadinga in mobile link channel has Nakagami *pdf* [9] :

$$p(\mu) = \frac{2m^m}{\Gamma(m)} \frac{\mu^{2m-1}}{\Omega^m} \exp\left(-\frac{m\mu^2}{\Omega}\right), \quad \mu \geq 0 \tag{1}$$

where m is fading parameter ($0.5 \le m < \infty$), $\Omega = \mu^2$, $\Gamma(\cdot)$ – gamma function. Value $m = 1$ is referring to Rayleigh fading, and for values $0.5 < m < 1$ fading is deeper than Rayleigh, if $m > 1$ fading is similar to Rice. Finally, $m \to \infty$ is referred to the case when there are no amplitude fluctuations. In macro cells it is: $0.5 \le m \le 1$, and in micro cells it is mostly $m > 1$.

Slow accidental changes of average power, Ω, have lognormal pdf:

$$p_\Omega(x) = \frac{1}{x\sqrt{2\pi\sigma^2}} \exp\left(-\frac{\ln^2(x/P_r)}{2\sigma^2}\right), \quad x > 0 \tag{2}$$

where P_r is average strength of recieved signal, σ is standard deviation. Lognormal *pdf* represents compromise between simple analytical form and adequate aproximation of measured results. If $\sigma \to 0$, there are no fluctuations of the slow fading. In practise, parameter σ is presented in dB, so, it is $\sigma_{dB} = 8.686\,\sigma$. Typical values for σ_{dB} (*shadowing spread* or *dB spread*) are from around 4 to 9 dB [13], and only in extreme cases to around 13 dB. Average power, P_r, of receiving signal depends on propagation model. Simplest case is

$$P_r = P_t C \left(\frac{d_0}{d}\right)^\alpha, \quad d \ge d_0 \tag{3}$$

where P_t is transmitted strength, C is constant which depends on anthenna characteristics of system, d is distance between reciever and transmitter, d_0 is referent distance, α is exponent which characterizes attenuation during transmittion path; $2 \le \alpha \le 4$ (exponent $\alpha = 2$ characterizes attenuation in free space). Alternative, P_r can be presented as a function of parameter in responding empirical propagation model- ex. Okumura – Hata model or as a function of complex theoretical – empirical model, ex. Ikegami model [12]. It is well known that (2) does not provide further operations of statistical averaging to be made in explicit form [13].

Approximation of lognormal distribution of shadowing with gamma distribution [17] presents significant step in analysis of composite fading influence on signals in specific modulation formats. Calculating average symbol error probability is simplified by presenting gamma pdf given as (4), instead of lognormal pdf, used before.

$$p_{\Omega}(x) = \frac{1}{\Gamma(m_s)} \left(\frac{m_s}{\Omega_s} \right)^{ms} x^{ms-1} \exp\left(-x \frac{m_s}{\Omega_s} \right) \tag{4}$$

where $x > 0$, $m_s > 0$.

Connection between parameters of lognormal *pdf* (σ_{dB}, P_r) and parameters of Gamma *pdf* (m_s,, Ω_s) is given as:

$$m_s = 1/(\exp(\sigma^2) - 1), \quad \Omega_s = P_r \sqrt{(m_s + 1)/m_s},$$

Parameter Ω_s presents modified average strength of recieved signal; in this context P_r is real average signal power. Aproximation proposed is adequate when $m_s \geq 0.5$, meaning $\sigma_{dB} < 9$ dB, which is in most cases in practise enough for calculations.

For the case when there is slow gamma and Nakagami fast fading, *pdf* of instantaneous signal to noise ratio is given in [6], so, we have:

$$f(\rho) = \frac{2}{\Gamma(m)\Gamma(m_s)} \left(\frac{mm_s}{\rho_0} \right)^{\frac{m+ms}{2}} \rho^{\frac{m+ms-2}{2}} K_{ms-m}\left(2\sqrt{\frac{mm_s}{\rho_0}\rho} \right) \tag{5}$$

where $K_\nu(\cdot)$ is modified Bessel function of second kind, and ν-th order, m is Nakagami fading parameter ($0.5 \leq m < \infty$), m_s is gamma fading parameter (in general, $m_s > 0$, and if *pdf* is a substitute for lognormal *pdf* then we have $m_s > 0.5$; value of this parameter is inverse proportional to depth of slow fading) and ρ_0 is average *snr* in channel in question.

It is known that Nakagami distribution is bad for Rice distribution approximation [10], [11], so, for the scenario of gamma slow Rice-fast fading, *pdf* is (6):

$$f(\rho) = \frac{2\exp(-K)}{\Gamma(m_s)} \left(\frac{(1+K)m_s}{\rho_0} \right)^{\frac{(ms+1)}{2}} \rho^{\frac{(ms-1)}{2}} \sum_{n=0}^{\infty} \frac{K^n}{(n!)^2} \left(\frac{(1+K)m_s}{\rho_0} \right)^{\frac{n}{2}} \cdot$$

$$\cdot \rho^{\frac{n}{2}} K_{ms-n-1}\left(2\sqrt{(1+K)m_s \frac{\rho}{\rho_0}} \right) \tag{6}$$

3. MGF approach

Expression that is used for static error probability for GMSK signal when there is noncoherent reciever in question [7], is (7) :

$$P_e(E) = \sum_{i=1}^{k} c_{1i} \exp(-c_{2i}\rho) \tag{7}$$

where coefficients c_{ij} (i,j=1,2; k=2) are:

$c_{11} = 0.329631(c_1)$;
$c_{12} = 0.00000000003575567\,(c_2)$;
$c_{21} = 0.597333(k_1)$;
$c_{22} = 0.961669(k_2)$

Expression for average error probability in channel with composite fading is gained by averaging of statistical error probability using statistical distributions for describing channel in function of scenario type (5), (6) :

$$P_s(\rho_0) = \int_0^{\infty} f(\rho) P_e(E)\,\mathrm{d}\rho \tag{8}$$

It is possible to get result (8) by using MGF method which in fact represents Laplace transform of *pdf* for instantaneous *snr*:

$$M_\rho(s) = \int_0^{\infty} f(\rho)\exp(-s\rho)\mathrm{d}\rho \tag{9}$$

So, for relations (5) i (6), MGF is given as (10), (11), respectively:

$$\begin{aligned} M_\rho(s) = {} & \left(\frac{mm_s}{s\rho_0}\right)^{ms} \frac{\Gamma(m-m_s)}{\Gamma(m)}\, {}_1F_1\!\left(m_s; m_s - m + 1; \frac{mm_s}{s\rho_0}\right) + \\ & + \left(\frac{mm_s}{s\rho_0}\right)^{m} \frac{\Gamma(m_s-m)}{\Gamma(m_s)}\, {}_1F_1\!\left(m; m - m_s + 1; \frac{mm_s}{s\rho_0}\right) \end{aligned} \tag{10}$$

$$M_\rho(s)=\exp(-K)\sum_{n=0}^{\infty}\frac{K^n}{(n!)^2}\left(\frac{(1+K)m_s}{s\rho_0}\right)^{ms}\cdot\Gamma(n-m_s+1)\,{}_1F_1\left(m_s;m_s-n;\frac{(1+K)m_s}{s\rho_0}\right)+$$

$$+\exp(-K)\sum_{n=0}^{\infty}\frac{K^n}{n!}\left(\frac{(1+K)m_s}{s\rho_0}\right)^{n+1}\frac{\Gamma(m_s-n-1)}{\Gamma(m_s)}\cdot{}_1F_1\left(n+1;n-m_s+2;\frac{(1+K)m_s}{s\rho_0}\right) \quad (11)$$

where ${}_1F_1(\cdot;\cdot;\cdot)$ is *Kummer* confluent hypergeometric function.

Putting (7) in (8), we get:

$$P_s(\rho_0)=\sum_{i=1}^{k}c_{1i}\int_0^{\infty}f(\rho)\exp(-c_{2i}\rho)\mathrm{d}\rho=\sum_{i=1}^{k}c_{1i}M_\rho(c_{2i}) \quad (12)$$

Relation (12) shows possibility of MGF method usage while calculating average error probability for noncoherent recieving of GMSK signal in channel with presence of composite fading. Reason for this is form of conditional error probability (exponential) which provides application of MGF method, meaning certain analytical advantages.

For scenarios in mobile channel which are described with distributions (5) i (6), error probability expressions are given as (13) i (14).

$$P_s(\rho_0)=\sum_{i=1}^{k}c_{1i}\left(\frac{mm_s}{c_{2i}\rho_0}\right)^{ms}\frac{\Gamma(m-m_s)}{\Gamma(m)}\,{}_1F_1\left(m_s;m_s-m+1;\frac{mm_s}{c_{2i}\rho_0}\right)+$$

$$+\sum_{i=1}^{k}c_{1i}\left(\frac{mm_s}{c_{2i}\rho_0}\right)^{m}\frac{\Gamma(m_s-m)}{\Gamma(m_s)}\,{}_1F_1\left(m;m-m_s+1;\frac{mm_s}{c_{2i}\rho_0}\right) \quad (13)$$

$$P_s(\rho_0)=\exp(-K)\sum_{i=1}^{k}c_{1i}\sum_{n=0}^{\infty}\frac{K^n}{(n!)^2}\left(\frac{(1+K)m_s}{c_{2i}\rho_0}\right)^{ms}\Gamma(n-m_s+1)\,{}_1F_1\left(m_s;m_s-n;\frac{(1+K)m_s}{s\rho_0}\right)+$$

$$+\exp(-K)\sum_{i=1}^{k}c_{1i}\sum_{n=0}^{\infty}\frac{K^n}{n!}\left(\frac{(1+K)m_s}{c_{2i}\rho_0}\right)^{n+1}\frac{\Gamma(m_s-n-1)}{\Gamma(m_s)}\,{}_1F_1\left(n+1;n-m_s+2;\frac{(1+K)m_s}{s\rho_0}\right) \quad (14)$$

Expression (13) responds to solution in paper [7], while (14) is refered to Rice-fast fading case added to gamma-slow fading.

4. Probability of outage

One more criteria for defining performances for system that is under the influence of fading is so called *outage probability* P_{out}, and presents probability for current value of error is higher than specific value, or equvivalent to previously said, probability for signal power-to-instantaneous interfering signal power ratio is below a specific protection ratio q (for example, about 12 dB for GSM system).

For calculating P_{out}, it is necessary to know function of probability density of random varijable Λ, which represents signal power-to-instantaneous interfering signal power ratio, $\Lambda = \frac{\rho_1}{\rho}$:

$$g(\Lambda) = \int_0^\infty f_I(\rho) f_D(\rho\Lambda) |\rho| \mathrm{d}\rho \tag{15}$$

where:

ρ_I – instantaneous signal to noise ratio for useful signal

ρ – instantaneous signal to noise ratio for interfering signal

$|\rho|$ – absolute value of Jacobian transformation $\Lambda = \frac{\rho_I}{\rho}$

$f_D(\rho)$, $f_I(\rho)$ – *pdf* for useful signal and interference, respectively

$$f_D(\rho_I) = \frac{2}{\Gamma(m)\Gamma(m_s)} \left(\frac{mm_s}{\rho_0}\right)^{\frac{m+ms}{2}} \rho_I^{\frac{m+ms-2}{2}} K_{ms-m}\left(2\sqrt{\frac{mm_s}{\rho_0}\rho_I}\right) \tag{16}$$

$$f_D(\rho) = \frac{2}{\Gamma(m_1)\Gamma(m_{s1})} \left(\frac{m_1 m_{s1}}{\rho_{01}}\right)^{\frac{m1+ms1}{2}} \rho^{\frac{m1+ms1-2}{2}} K_{ms1-m1}\left(2\sqrt{\frac{m_1 m_{s1}}{\rho_{01}}\rho}\right) \tag{17}$$

By using (16) i (17) in (15), after useful transformations [17], we get:

$$g(\Lambda) = c^{ms} b \cdot \Lambda^{ms-1} {}_2F_1(m_s + m_{s1}, m_1 + m_s; m + m_s + m_1 + m_{s1}; 1 - c\Lambda) \tag{18}$$

where:

$$c = \frac{mm_s}{m_1 m_{s1}} \frac{\rho_{01}}{\rho_0} = \frac{mm_s}{m_1 m_{s1}} \frac{1}{SIR_{av}}, \quad b = \frac{B(m_1 + m_s, m + m_{s1})}{B(m, m_1) B(m_s, m_{s1})}$$

$B(\cdot,\cdot)$ is beta function, ${}_2F_1(\cdot\,, \cdot\,; \cdot\,; \cdot)$ Gauss hyper geometric function

Mathematically presented, calculation of P_{out} is performed in following way:

$$P_{out} = \int_0^q g(\Lambda)\mathrm{d}\Lambda$$

$$P_{out} = g_1 (cq)^{ms} \times\times {}_3F_2(m_s, m_s + m_{s1}, m_1 + m_s; m_s - m + 1, m_s + 1; cq) +$$

$$+ g_2 (cq)^m \times\times {}_3F_2(m, m + m_{s1}, m + m_1; m - m_s + 1, m + 1; cq)] \qquad (19)$$

where:

$$g_1 = \frac{\Gamma(m - m_s)\Gamma(m_1 + m_s)\Gamma(m_s + m_{s1})}{m_s\Gamma(m)\Gamma(m_1)\Gamma(m_s)\Gamma(m_{s1})},$$

$$g_2 = \frac{\Gamma(m_s - m)\Gamma(m + m_1)\Gamma(m + m_{s1})}{m\Gamma(m)\Gamma(m_1)\Gamma(m_s)\Gamma(m_{s1})}$$

$$SIR_{av} = \frac{\rho_0}{\rho_{01}} = \left(\frac{d_1}{d}\right)^{\alpha} \sqrt{\frac{(1 + m_s)m_{s1}}{(1 + m_{s1})m_s}},$$

$$cq = \frac{mm_s}{m_1 m_{s1}} \frac{G}{\Lambda_d} q = \frac{mm_s}{m_1 m_{s1}} \frac{G}{\left(\frac{\Lambda_d}{q}\right)} = \frac{B}{x}$$

$$B = \frac{mm_s}{m_1 m_{s1}} G; \quad x = \frac{\Lambda_d}{q}, \quad m - m_s \notin Z$$

It's important to note that results given in this paper are different from one in [6], because curves (Graphics 5-8) have expecting form; mentioned phenomenon [6] doesn't exist.

5. Results

Graphical presentation of expressions (13) and (14) is given in figures 1-4. Graphics in question are refered to curves of symbol error probability for GMSK signal in function of scenario type in channel; Figures 1 i 2 are refered to case of Nakagami-fast fading superimposed to gamma slow fading, while figures 3 i 4 instead of Nakagami use Rice distribution of fast fading.

Graphics in figures 5-8 point to dependence of outage probability on channel parameters values.

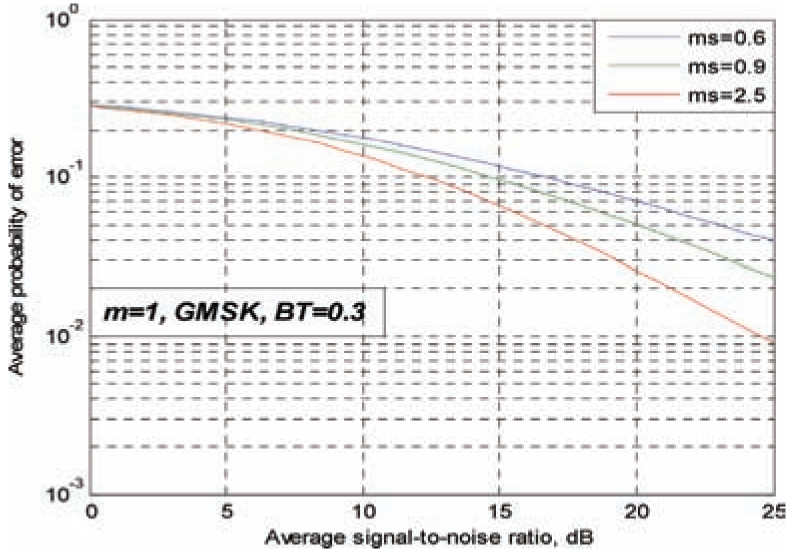

Figure 1. Error probability for noncoherent reciever of GMSK signal in channel with presence of composite fading

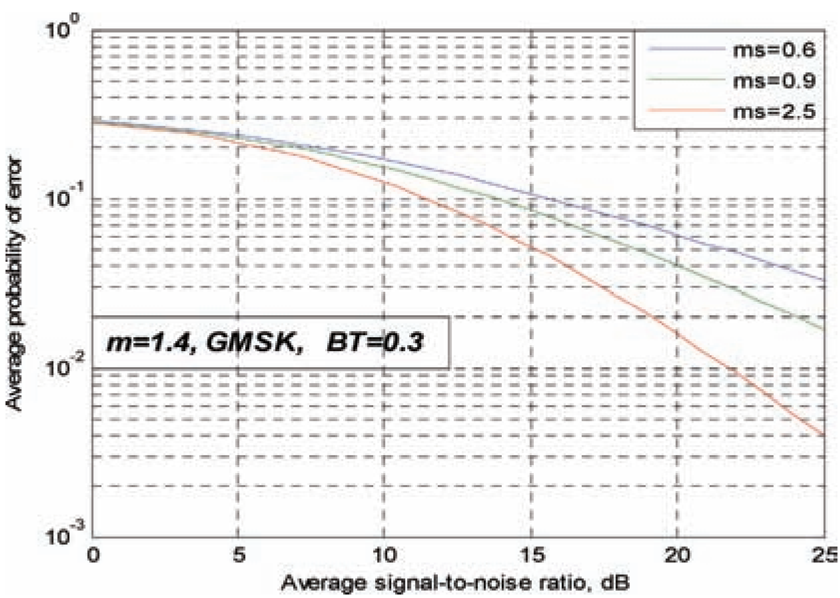

Figure 2. Error probability for noncoherent reciever of GMSK signal in channel with presence of composite fading

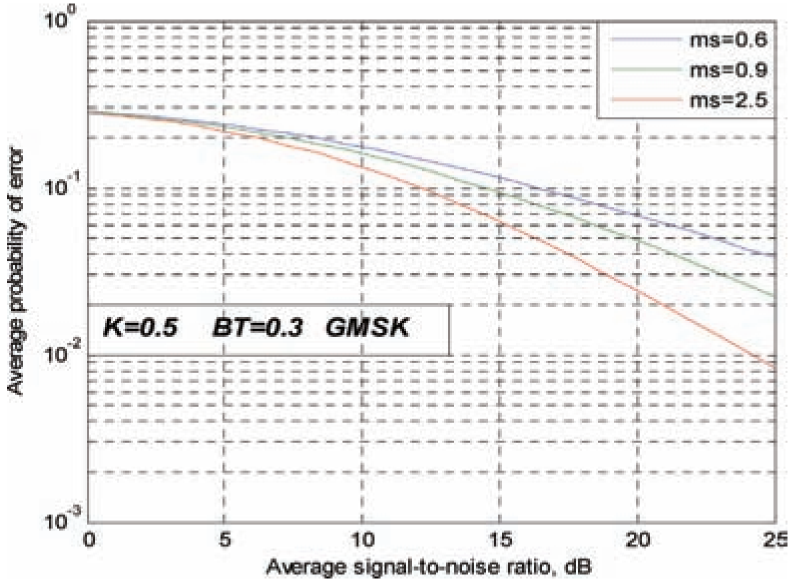

Figure 3. Error probability for noncoherent reciever of GMSK signal in channel with presence of composite fading

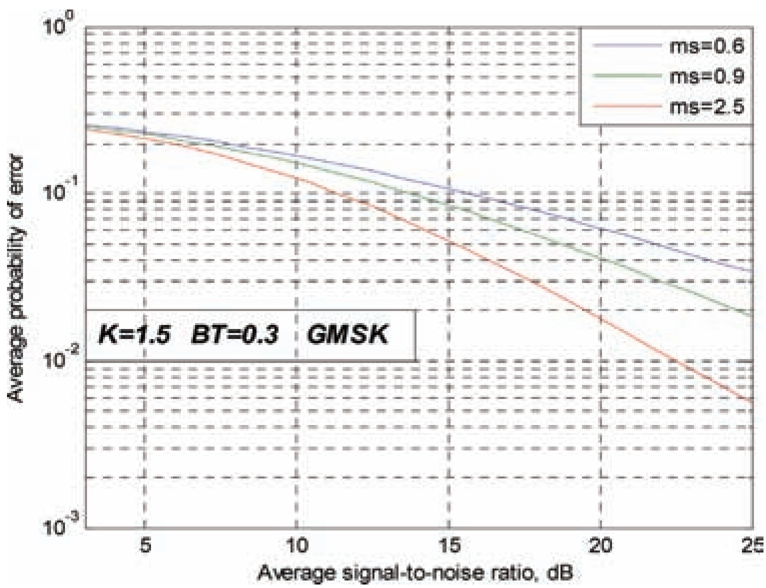

Figure 4. Error probability for noncoherent reciever of GMSK signal in channel with presence of composite fading

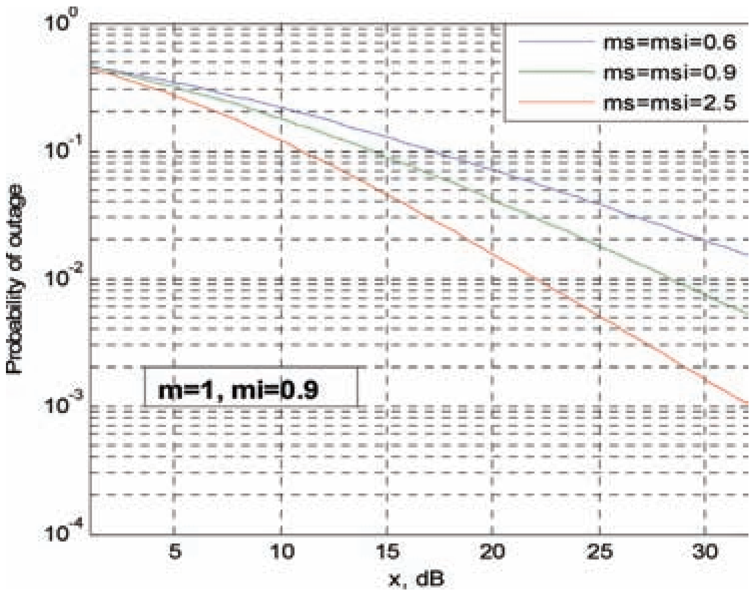

Figure 5. Probability of outage in channel with presence of composite fading

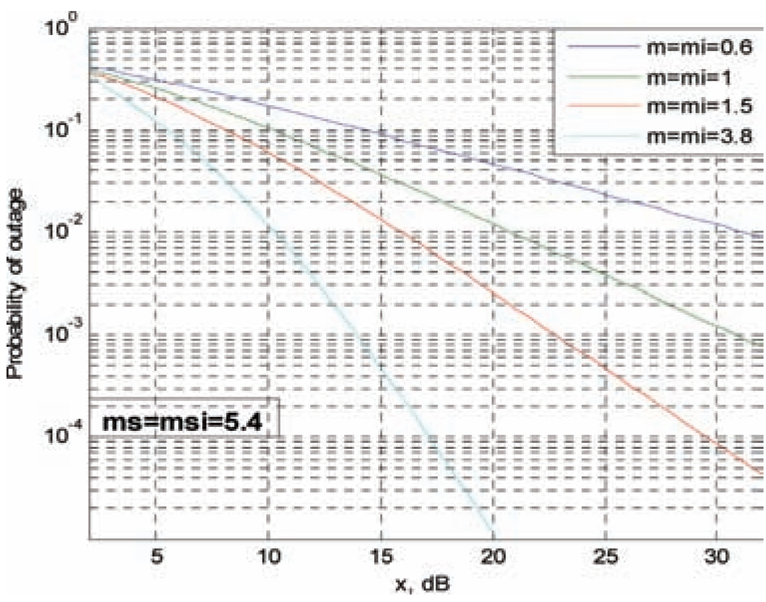

Figure 6. Probability of outage in channel with presence of composite fading

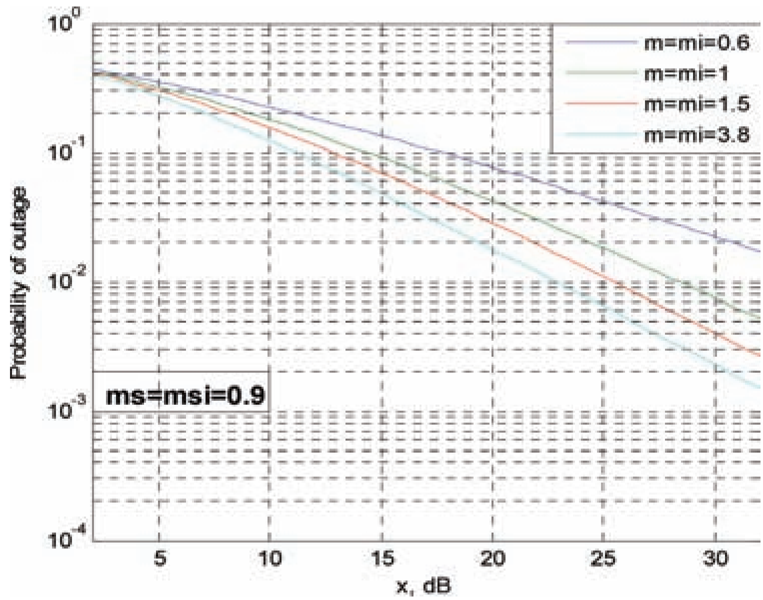

Figure 7. Probability of outage in channel with presence of composite fading

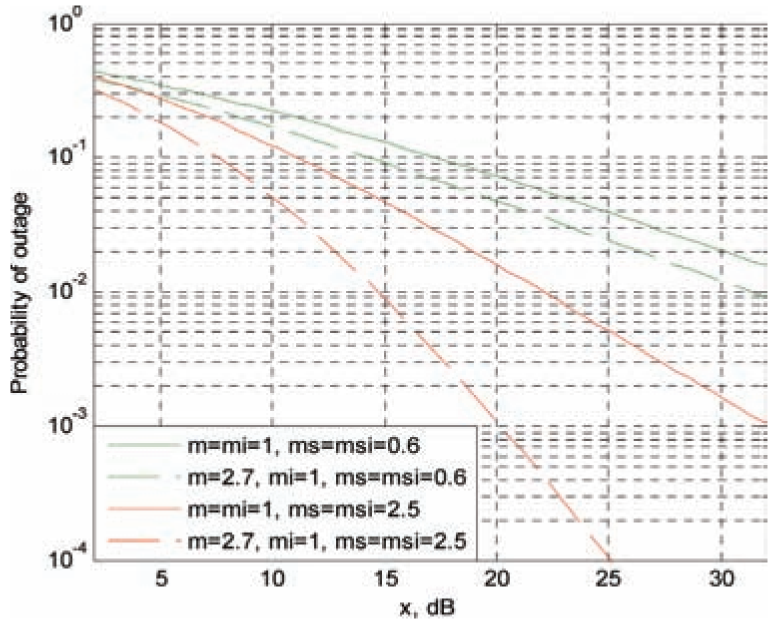

Figure 8. Probability of outage in channel with presence of composite fading

6. Conclusions

In this paper expressions for the simbol error probability for noncoherent reciever for GMSK signal in channel with presence of composite fading. Analytical advantages provided by MGF method are used as well as in the case of coherent recievers. Expressions obtained are similar to already existing ones in the literature which confirms accuracy of methods that have been used. While generating the results, spectrum width that is considered is similar to the one in actual usage of GMSK modulation format in GSM.

Also, scenario which consideres Rice distribution of fast fading is observed.

Results obtained for the outage probability point to dependence between link quality and channel parameters that define scenario attached to useful signal or interference signal. Graphics show that there is more dependence between curves and shadowing parameter, m_s, than it would be the case with fading parameter m. Goal of further research will be application of MGF method on coherent reciever, because this type of reciever is present in current cellular networks.

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Scalar Wave Effects according to Tesla

Field-physical basis for electrically coupled bidirectional far range transponders, such as Tesla's Wardenclyffe Tower

Abstract

With the current RFID technology the transfer of energy takes place on a chip card by means of longitudinal wave components in close range of the transmitting antenna. Those are scalar waves, which spread towards the electrical or the magnetic field pointer.

In the wave equation with reference to the Maxwell field equations, these wave components are set to zero, why only postulated model computations exist, after which the range is limited to the sixth part of the wavelength.

A goal of this paper is to create, by consideration of the scalar wave components in the wave equation, the physical conditions for the development of scalar wave transponders which are operable beyond the close range. The energy is transferred with the same carrier wave as the information and not over two separated ways as with RFID systems. Besides the bi-directional signal transmission, the energy transfer in both directions is additionally possible because of the resonant coupling between transmitter and receiver.

First far range transponders developed on the basis of the extended field equations are already functional as prototypes, according to the US-Patent No. 787,412 of Nikola Tesla, New York 1905 [1].

Key words

Longitudinal wave, scalar wave, Tesla radiation, RFID, field theory.

1. Introduction

Abstract of the practical setting of tasks

Transponders serve the transmission of energy e.g. on a chip card in combination with a back transmission of information. The range is with the presently marketable devices (RFID technology) under one meter [2]. The energy receiver must be in addition in close range of the transmitter.

The far range transponders developed by the first transfer centre for scalar wave technology are able to transfer energy beyond close range (10 to 100 m) and besides with fewer losses and/or a higher efficiency. The energy with the same carrier wave is transferred as the information and not as with the RFID technology over two separated systems [2].

A condition for new technologies is a technical-physical understanding, as well as a mathematically correct and comprehensive field description, which include all well known effects of close range of an antenna. We encounter here a central problem of the field theory, which forms the emphasis of this paper and the basis for advancements in the transponder technology.

Requirements at transponders

In today's times of Blue tooth and Wireless LAN one accustomed fast to the amenities of wireless communication. These open for example garage gates, the barrier of the parking lot or the trunk is lid only by radio.

However, in the life span limited and the often polluting batteries in the numerous radio transmitters and remote maintenance are of great disadvantage.

Ever more frequently the developers see themselves confronted with the demand after a wireless transfer of energy. Accumulators are to be reloaded or replaced completely. In entrance control systems (ski elevator, stages, department stores…) these systems are already successful in use.

But new areas of application with increased requirements are constantly added apart from the desire for a larger range:

- *in telemetry plants rotary sensors are to be supplied with energy (in the car e.g. to control tire pressure).*
- *also with heat meters the energy should come from a central unit and be spread wirelessly in the whole house to the heating cost meters without the use of batteries*
- *in airports contents of freight containers are to be seized, without these to having be opened (security checks).*
- *the forwarding trade wants to examine closed truck charges by transponder technology.*
- *in the robot and handling technique the wirings are to be replaced by a wireless technology (wear problem).*
- *portable radio devices, mobile phones, Notebooks and remote controls working without batteries and Accumulators (reduction of the environ-mental impact).*

A technical solution, which is based on pure experimenting and trying, is to be optimised unsatisfactorily and hardly. It should stand rather on a field-theoretically secured foundation, whereby everyone thinks first of Maxwell's field equations. Here however a new hurdle develops itself under close occupation.

Problem of the field theory

In the close range of an antenna, so the current level of knowledge is, are longitudinal -towards a field pointer, portions of the radiated wave present. These are usable in the transponder technology for the wireless transmission of energy. The range amounts to however only $\lambda/2\pi$ and that is approximately the sixth part of the wavelength [3].

The problem consists now of the fact that the valid field theory, and that is from Maxwell, only is able to describes transversal and no longitudinal wave components. All computations of longitudinal waves or wave components, which run toward the electrical or the magnetic pointer of the field, are based without exception on postulates [4].

The near field is not considered in vain as an unresolved problem of the field theory. The experimental proof may succeed, not however the field-theoretical proof.

Field equations according to Maxwell

A short derivation brings it to light. We start with the law of induction according to the textbooks

$$\boxed{\text{curl } \mathbf{E} = -\,\delta\mathbf{B}/\delta t} \tag{1.1}$$

with the electric field strength $\mathbf{E} = \mathbf{E}(\mathbf{r},t)$ and the magnetic field strength $\mathbf{H} = \mathbf{H}(\mathbf{r},t)$

and: $$\mathbf{B} = \mu \cdot \mathbf{H} \text{ (1. relation of material),} \tag{1.2}$$

apply the curl-operation to both sides of the equation

$$-\text{ curl curl } \mathbf{E} = \mu \cdot \delta(\text{curl } \mathbf{H})/\delta t \tag{1.3}$$

and insert in the place of curl **H** Ampere's law:

$$\text{curl } \mathbf{H} = \mathbf{j} + \delta\mathbf{D}/\delta t \tag{1.4}$$

with $$\mathbf{j} = \sigma \cdot \mathrm{E} \text{ (Ohm's law)} \tag{1.5}$$

with $$\mathbf{D} = \varepsilon \cdot \mathrm{E} \text{ (2. relation of material)} \tag{1.6}$$

and $$\tau_1 = \varepsilon/\sigma \text{ (relaxation time [5])} \tag{1.7}$$

$$\boxed{\text{curl } \mathbf{H} = \varepsilon \cdot (\mathbf{E}/\tau_1 + \delta\mathbf{E}/\delta t)} \tag{1.8}$$

$$-\text{ curl curl } \mathbf{E} = \mu \cdot \varepsilon \cdot (1/\tau_1 \cdot \delta\mathbf{E}/\delta t + \delta^2\mathbf{E}/\delta t^2) \tag{1.9}$$

with the abbreviation: $$\mu \cdot \varepsilon = 1/c^2. \tag{1.10}$$

The generally known result describes a *damped electro-magnetic wave* [6]:

$$\boxed{\underbrace{-\text{ curl curl } \mathbf{E} \cdot c^2}_{\text{transverse}} = \underbrace{\delta^2\mathbf{E}/\delta t^2}_{\text{– wave}} + \underbrace{(1/\tau_1) \cdot \delta\mathbf{E}/\delta t}_{\text{+ vortex damping}}} \tag{1.11}$$

On the one hand it is a transverse wave. On the other hand there is an damping term in the equation, which is responsible for the losses of an antenna. It indicates the wave component, which is converted into standing waves, which can be also called field vortices, that produce vortex losses for their part with the time constant τ_1 in the form of heat.

Where however do, at close range of an antenna proven and with transponders technically used longitudinal wave components hide themselves in the field equation (1.11)?

Wave equation according to Laplace

The wave equation found in most textbooks has the form of an inhomogeneous Laplace equation. The famous French mathematician ***Laplace*** considerably earlier than Maxwell did find a comprehensive formulation of waves and formulated it mathematically:

$$\underbrace{\Delta \mathbf{E} \cdot c^2}_{\text{Laplace operator}} = \underbrace{- \text{curl curl } \mathbf{E} \cdot c^2}_{\text{transverse- (radio wave)}} + \underbrace{\text{grad div } \mathbf{E} \cdot c^2}_{\text{longitudinal- (scalar wave)}} = \underbrace{\delta^2 \mathbf{E}/\delta t^2}_{\text{wave}} \qquad (1.12)$$

On the one side of the wave equation the Laplace operator stands, which describes the spatial field distribution and which according to the rules of vector analysis can be decomposed into two parts. On the other side the description of the time dependency of the wave can be found as an inhomogeneous term.

The wave equations in the comparison

If the wave equation according to Laplace (1.12) is compared to the one, which the Maxwell equations have brought us (1.11), then two differences clearly come forward:

1. *In the Laplace equation the damping term is missing.*

2. *With divergence **E** a scalar factor appears in the wave equation, which founds a scalar wave.*

One practical example of a scalar wave is the plasma wave. This case forms according to the

3. Maxwell equation: $\text{div } \mathbf{D} = \varepsilon \cdot \text{div } \mathbf{E} = \rho_{el}$ (1.13)

the space charge density consisting of charge carriers ρ_{el} the scalar portion. These move in form of a shock wave longitudinal forward and present in its whole an electric current.

Since both descriptions of waves possess equal validity, we are entitled in the sense of a coefficient comparison to equate the damping term due to eddy currents according to Maxwell (1.11) with the scalar wave term according to Laplace (1.12).

Physically seen the generated field vortices form and establish a scalar wave.

The presence of div **E** proves a necessary condition for the occurrence of eddy currents. Because of the well known skin effect [7] expanding and damping acting eddy currents, which appear as consequence of a current density **j** , set ahead however an electrical conductivity σ (acc. to eq. 1.5).

The view of duality

Within the near field range of an antenna opposite conditions are present. With bad conductivity in a general manner a vortex with dual characteristics would be demanded for the formation of longitudinal wave components. I want to call this contracting antivortex, unlike to the expanding eddy current, a potential vortex.

If we examine the potential vortex with the Maxwell equations for validity and compatibility, then we would be forced to let it fall directly again. The derivation of the damped wave equation (1.1 to 1.11) can take place in place of the electrical, also for the magnetic field strength. Both wave equations (1.11 and 1.12) do not change thereby their shape. In the inhomogeneous Laplace equation in this dual case however, the longitudinal scalar wave component through div **H** is described and this is according to Maxwell zero!

4. Maxwell's equation: $\quad \text{div}\,\mathbf{B} = \mu \cdot \text{div}\,\mathbf{H} = 0 \quad (1.14)$

If is correct, then there may not be a near field, no wireless transfer of energy and finally also no transponder technology. Therefore, the correctness is permitted (of eq. 1.14) to question and examine once, what would result thereby if potential vortices exist and develop in the air around an antenna scalar waves, as the field vortices form among themselves a shock wave.

Besides still another boundary problem will be solved: since in div **D** electrical monopoles can be seen (1.13) there should result from duality to div **B** magnetic monopoles (1.14). But the search was so far unsuccessful [8]. Vortex physics will ready have an answer.

2. The approach

Faraday instead of Maxwell

If a measurable phenomenon should, e.g. the close range of an antenna, not be described with the field equations according to Maxwell mathematically, then prospect is to be held after a new approach. All efforts that want to prove the correctness of the Maxwell theory with the Maxwell theory end inevitably in a tail-chase, which does not prove anything in the end.

In a new approach high requirements are posed. It may not contradict the Maxwell theory, since these supply correct results in most practical cases and may be seen as confirmed. It would be only an extension permissible, in which the past theory is contained as a subset e.g. Let's go on the quest.

Vortex and anti-vortex

In the eye of a tornado the same calm prevails as at great distance, because here a vortex and its anti-vortex work against each other. In the inside the expanding vortex is located and on the outside the contracting anti-vortex. One vortex is the condition for the existence of the other one and vice versa. Already ***Leonardo da Vinci*** knew both vortices and has described the dual manifestations [9].

In the case of flow vortices the viscosity determines the diameter of the vortex tube where the coming off will occur. If for instance a tornado soaks itself with water above the open ocean, then the contracting potential vortex is predominant and the energy density increases threateningly. If it however runs overland and rains out, it again becomes bigger and less dangerous.

In fluidics the connections are understood. They are usually also well visible and without further aids observable.

In electrical engineering it's different: here field vortices remain invisible. Only so a theory could find acceptance, although it only describes mathematically the expanding eddy current and ignores its anti-vortex. I call the contracting anti-vortex "potential vortex" and point to the circumstance, that every eddy current entails the anti-vortex as a physical necessity.

By this reconciliation it is ensured that the condition in the vortex centre corresponds in the infinite one, complete in analogy to fluid mechanics.

The Maxwell approximation

The approximation, which is hidden in the Maxwell equations, thus consists of neglecting the anti-vortex dual to the eddy current. It is possible that this approximation is allowed, as long as it only concerns processes inside conducting materials. The transition to insulants however, which requires for the laws of the field refraction steadiness, is incompatible with the acceptance of eddy currents in the cable and a nonvortical field in air. In such a case the Maxwell approximation will lead to considerable errors.

If we take as an example the lightning and ask how the lightning channel is formed: Which mechanism is behind it, if the electrically insulating air for a short time is becoming a conductor? From the viewpoint of vortex physics the answer is obvious: The potential vortex, which in the air is dominating, contracts very strong and doing so squeezes all air charge carriers and air ions, which are responsible for the conductivity, together at a very small space to form a current channel.

The contracting potential vortex thus exerts a pressure and with that forms the vortex tube. Besides the cylindrical structure another structure can be expected. It is the sphere, which is the only form, which can withstand a powerful pressure if that acts equally from all directions of space. Only think of ball lightning.

We imagine now a spherical vortex, in whose inside an expanding vortex is enclosed and which is held together from the outside by the contracting potential vortex and is forced into it's spherical shape. From the infinite measured this spherical vortex would have an electrical charge and all the characteristics of a charge carrier.

Inside:	expanding eddy current (skin effect)
Outside:	contracting anti-vortex (potential vortex)
Condition:	for coming off: equally powerful vortices
Criterion:	electric conductivity (determines diameter)
Result:	spherical structure (consequence of the pressure of the vacuum)

Figure 2. The electron as an electromagnetic sphere-vortex

The mistake of the magnetic monopole

With the tendency of the potential vortex for contraction, inevitably the ability is linked to a structural formation. The particularly obvious structure of a ball would be besides an useful model for quanta.

A to the sphere formed field-vortex would be described mathematically in its inside with the expanding vortex div **D**. For the potential vortex working against from the outside div **B** would apply.

The divergence may be set therefore neither with the electrical field (4th Maxwell equation) nor with the magnetic field (3rd Maxwell equation) to zero!

If however both equations are necessary for the derivation of an electron, then it is a mistake in reasoning wanting to assign one alone to an electrical and the other one to a magnetic monopole.

Since the radius, at which it comes to vortex detaching and with it the size of the sphere vortex depends on it's conductivity, electrical monopoles and among them rank numerous elementary particles, will be extremely small. Magnetic monopoles however would have to take enormous, no longer for us measurable dimensions.

The discovery of the law of induction

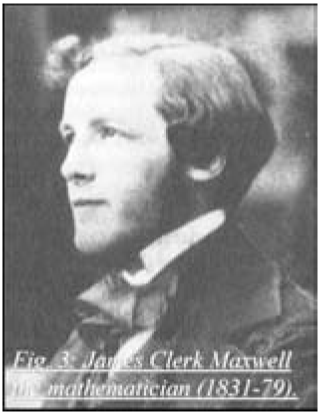

Fig. 3: James Clerk Maxwell the mathematician (1831-79).

In the choice of the approach the physicist is free, as long as the approach is reasonable and well founded. In the case of Maxwell's field equations two experimentally determined regularities served as basis: on the one hand Ampère's law and on the other hand the law of induction of Faraday. The mathematician Maxwell thereby gave the finishing touches for the formulations of both laws. He introduced the displacement current D and completed Ampère's law accordingly, and that without a chance of already at his time being able to measure and prove the measure. Only after his death this was possible experimentally, what afterwards makes clear the format of this man.

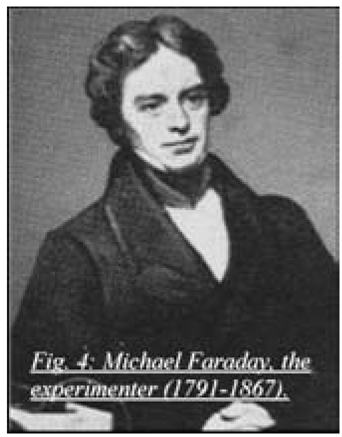

Fig. 4: Michael Faraday, the experimenter (1791-1867).

In the formulation of the law of induction Maxwell was completely free, because the discoverer ***Michael Faraday*** had done without specifications. As a man of practice and of experiment the mathematical notation was less important for Faraday. For him the attempts with which he could show his discovery of the induction to everybody, e.g. his unipolar generator, stood in the foreground.

His 40 years younger friend and professor of mathematics Maxwell however had something completely different in mind. He wanted to describe the light as an electromagnetic wave and doing so certainly the wave description of Laplace went through his mind, which needs a second time derivation of the field factor.

Because Maxwell for this purpose needed two equations with each time a first derivation, he had to introduce the displacement current in Ampère's law and had to choose an appropriate notation for the formulation of the law of induction to get to the wave equation.

His light theory initially was very controversial. Maxwell faster found acknowledgement for bringing together the teachings of electricity and magnetism and the representation as something unified and belonging together [10] than for mathematically giving reasons for the principle discovered by Faraday.

Nevertheless the question should be asked, if Maxwell has found the suitable formulation, if he has understood 100 percent correct his friend Faraday and his discovery. If discovery (from 29.08.1831) and mathematical formulation (1862) stem from two different scientists, who in addition belong to different disciplines, misunderstandings are nothing unusual. It will be helpful to work out the differences.

The unipolar generator

If one turns an axially polarized magnet or a copper disc situated in a magnetic field, then perpendicular to the direction of motion and perpendicular to the magnetic field pointer a pointer of the electric field will occur, which everywhere points axially to the outside. In the case of this by Faraday developed unipolar generator hence by means of a brush between the rotation axis and the circumference a tension voltage can be called off.

The mathematically correct relation

$$\mathbf{E} = \mathbf{v} \times \mathbf{B} \tag{2.1}$$

I call Faraday-law, even if it only appears in this form in the textbooks later in time [11]. The formulation usually is attributed to the mathematician ***Hendrik Lorentz***, since it appears in the Lorentz force in exactly this form. Much more important than the mathematical formalism however are the experimental results and the discovery by Michael Faraday, for which reason the law concerning unipolar induction is named after the discoverer. Of course we must realize that the charge carriers at the time of the discovery hadn't been discovered yet and the field concept couldn't correspond to that of today.

The field concept was an abstracter one, free of any quantisation.

That of course also is valid for the field concept advocated by Maxwell, which we now contrast with the "Faraday-law" (fig. 5). The second Maxwell equation, the law of induction (2.2), also is a mathematical description between the electric field strength **E** and the magnetic induction **B**. But this time the two aren't linked by a relative velocity **v**.

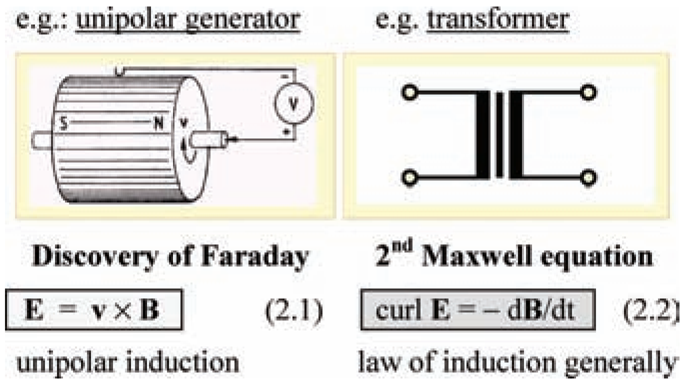

Figure 5. Two formulations for one law: As a mathematical relation between the vectors of the electric field strength **E** and the induction **B** (= magnetic flux density)

In that place stands the time derivation of **B**, with which a change in flux is necessary for an electric field strength to occur. As a consequence the Maxwell equation doesn't provide a result in the static or quasi-stationary case, for which reason it in such cases is usual, to fall back upon the unipolar induction according to Faraday (e.g. in the case of the Hall-probe, the picture tube, etc.). The falling back should only remain restricted to such cases, so the normally used idea. But with which right the restriction of the Faraday-law to stationary processes is made?

The vectors **E** and **B** can be subject to both spatial and temporal fluctuations. In that way the two formulations suddenly are in competition with each other and we are asked, to explain the difference, as far as such a difference should be present.

Different induction laws

Such a difference for instance is that it is common practice to neglect the coupling between the fields at low frequencies. While at high frequencies in the range of the electromagnetic field the **E**- and the **H**-field are mutually dependent, at lower frequency and small field change the process of induction drops correspondingly according to Maxwell, so that a neglect seems to be allowed. Now electric or magnetic field can be measured independently of each other. Usually is proceeded as if the other field is not present at all.

That is not correct. A look at the Faraday-law immediately shows that even down to frequency zero always both fields are present. The field pointers however stand perpendicular to each other, so that the magnetic field pointer wraps around the pointer of the electric field in the form of a vortex ring in the case that the electric field strength is being measured and vice versa. The closed-loop field lines are acting neutral to the outside; they hence need no attention, so the normally used idea. It should be examined more closely if this is sufficient as an explanation for the neglect of the not measurable closed-loop field lines, or if not after all an effect arises from fields, which are present in reality.

Another difference concerns the commutability of **E**- and **H**-field, as is shown by the Faraday-generator, how a magnetic becomes an electric field and vice versa as a result of a relative velocity v. This directly influences the physical-philosophic question: What is meant by the electromagnetic field?

The electromagnetic field

The textbook opinion based on the Maxwell equations names the static field of the charge carriers as cause for the electric field, whereas moving ones cause the magnetic field [7, i.e.]. But that hardly can have been the idea of Faraday, to whom the existence of charge carriers was completely unknown. For his contemporaries, completely revolutionary abstract field concept, based on the works of the Croatian Jesuit priest ***Boscovich*** (1711-1778). In the case of the field it should less concern a physical quantity in the usual sense, than rather the “experimental experience” of an interaction according to his field description. We should interpret the Faraday-law to the effect that we experience an electric field, if we are moving with regard to a magnetic field with a relative velocity and vice versa.

In the commutability of electric and magnetic field a duality between the two is expressed, which in the Maxwell formulation is lost, as soon as charge carriers are brought into play. Is thus the Maxwell field the special case of a particle free field? Much evidence points to it, because after all a light ray can run through a particle free vacuum. If however fields can exist without particles, particles without fields however are impossible, then the field should have been there first as the cause for the particles. Then the Faraday description should form the basis, from which all other regularities can be derived.

What do the textbooks say to that?

Contradictory opinions in textbooks

Obviously there exist two formulations for the law of induction (2.1 and 2.2), which more or less have equal rights. Science stands for the question: which mathematical description is the more efficient one? If one case is a special case of the other case, which description then is the more universal one?

What Maxwell's field equations tell us is sufficiently known, so that derivations are unnecessary. Numerous textbooks are standing by, if results should be cited. Let us hence turn to the Faraday-law (2.1). Often one searches in vain for this law in schoolbooks. Only in more pretentious books one makes a find under the keyword "unipolar induction". If one however compares the number of pages, which are spent on the law of induction according to Maxwell with the few pages for the unipolar induction, then one gets the impression that the latter only is a unimportant special case for low frequencies. ***Küpfmüller*** speaks of a "special form of the law of induction" [12], and cites as practical examples the induction in a brake disc and the Hall-effect. Afterwards Küpfmüller derives from the "special form" the "general form" of the law of induction according to Maxwell, a postulated generalization, which needs an explanation. But a reason is not given [12].

Bosse gives the same derivation, but for him the Maxwell-result is the special case and not his Faraday approach [13]! In addition he addresses the Faraday-law as equation of transformation and points out the meaning and the special interpretation.

On the other hand he derives the law from the Lorentz force, completely in the style of Küpfmüller [12] and with that again takes it part of its autonomy.

Pohl looks at that different. He inversely derives the Lorentz force from the Faraday-law [14]. We should follow this very much convincing representation.

The equation of convection

If the by Bosse [13] prompted term "equation of transformation" is justified or not at first is unimportant. That is a matter of discussion.

If there should be talk about equations of transformation, then the dual formulation (to equation 2.1) belongs to it, then it concerns a pair of equations, which describes the relations between the electric and the magnetic field.

The **new and dual field approach** consists of

equations of transformation

of the electric and of the magnetic field

$$\mathbf{E} = \mathbf{v} \times \mathbf{B} \quad (2.1) \quad \text{and} \quad \mathbf{H} = -\mathbf{v} \times \mathbf{D} \quad (2.3)$$

unipolar induction — equation of convection

Written down according to the rules of duality there results an equation (2.3), which occasionally is mentioned in some textbooks.

While both equations in the books of Pohl [14, p.76 and 130] and of ***Simonyi*** [15] are written down side by side having equal rights and are compared with each other, ***Grimsehl*** [16] derives the dual regularity (2.3) with the help of the example of a thin, positively charged and rotating metal ring. He speaks of “equation of convection”, according to which moving charges produce a magnetic field and so-called convection currents. Doing so he refers to workings of *Röntgen* 1885, *Himstedt, Rowland* 1876, *Eichenwald* and many others more, which today hardly are known.

In his textbook also Pohl gives practical examples for both equations of transformation. He points out that one equation changes into the other one, if as a relative velocity v the speed of light c should occur.

3. Derivation from text book physics

We now have found a field-theoretical approach with the equations of transformation, which in its dual formulation is clearly distinguished from the Maxwell approach. The reassuring conclusion is added: ***The new field approach roots entirely in textbook physics***, as are the results from the literature research. We can completely do **without postulates**.

Next thing to do is to test the approach strictly mathematical for freedom of contradictions. It in particular concerns the question, which known regularities can be derived under which conditions. Moreover the conditions and the scopes of the derived theories should result correctly, e.g. of what the Maxwell approximation consists and why the Maxwell equations describe only a special case.

Derivation of the field equations acc. to Maxwell

As a starting-point and as approach serve the equations of transformation of the electromagnetic field, the Faraday-law of *unipolar induction* (2.1) and the according to the rules of duality formulated law called *equation of convection* (2.3).

$$\mathbf{E} = \mathbf{v} \times \mathbf{B} \tag{2.1}$$

and

$$\mathbf{H} = -\mathbf{v} \times \mathbf{D} \tag{2.3}$$

If we apply the curl to both sides of the equations:

$$\text{curl } \mathbf{E} = \text{curl } (\mathbf{v} \times \mathbf{B}) \tag{3.1}$$

and

$$\text{curl } \mathbf{H} = -\text{curl } (\mathbf{v} \times \mathbf{D}) \tag{3.2}$$

then according to known algorithms of vector analysis the curl of the cross product each time delivers the sum of four single terms [17]:

$$\text{curl } \mathbf{E} = (\mathbf{B} \text{ grad})\mathbf{v} - (\mathbf{v} \text{ grad})\mathbf{B} + \mathbf{v} \text{ div } \mathbf{B} - \mathbf{B} \text{ div } \mathbf{v} \tag{3.3}$$

$$\text{curl } \mathbf{H} = -[(\mathbf{D} \text{ grad})\mathbf{v} - (\mathbf{v} \text{ grad})\mathbf{D} + \mathbf{v} \text{ div } \mathbf{D} - \mathbf{D} \text{ div } \mathbf{v}] \tag{3.4}$$

Two of these again are zero for a non-accelerated relative motion in the x-direction with:

$$\mathbf{v} = d\mathbf{r}/dt \tag{3.5}$$

$$\text{grad } \mathbf{v} = 0 \tag{3.5*}$$

and

$$\text{div } \mathbf{v} = 0 \tag{3.5**}$$

One term concerns 'the vector gradient ($\mathbf{v}$ grad)$\mathbf{B}$, which can be represented as a tensor. By writing down and solving the accompanying derivative matrix giving consideration to the above determination of the $\mathbf{v}$-vector, the vector gradient becomes the simple time derivation of the field vector $\mathbf{B}(\mathbf{r}(t))$,

$$(\mathbf{v}\ \text{grad})\mathbf{B} = \frac{d\mathbf{B}}{dt} \quad \text{and} \quad (\mathbf{v}\ \text{grad})\mathbf{D} = \frac{d\mathbf{D}}{dt}, \tag{3.6}$$

according to the rule [17]:

$$\frac{d\mathbf{V}(\mathbf{r}(t))}{dt} = \frac{\partial \mathbf{V}(\mathbf{r} = \mathbf{r}(t))}{\partial \mathbf{r}} \cdot \frac{d\mathbf{r}(t)}{dt} = (\mathbf{v}\ \text{grad})\mathbf{V}. \tag{3.7}$$

For the last not yet explained terms at first are written down the vectors $\mathbf{b}$ and $\mathbf{j}$ as abbreviation.

$$\text{curl}\ \mathbf{E} = -\ d\mathbf{B}/dt + \mathbf{v}\ \text{div}\ \mathbf{B} = -\ d\mathbf{B}/dt - \mathbf{b} \tag{3.8}$$

$$\text{curl}\ \mathbf{H} = d\mathbf{D}/dt - \mathbf{v}\ \text{div}\ \mathbf{D} = d\mathbf{D}/dt + \mathbf{j} \tag{3.9}$$

With equation 3.9 we in this way immediately look at the well-known law of Ampère (1st Maxwell equation).

The Maxwell equations as a special case

The result will be the **Maxwell equations**, if:

- the potential density $\mathbf{b} = -\ \mathbf{v}\ \text{div}\ \mathbf{B} = 0$, (3.10)
  (eq. 3.8 ≡ law of induction 1.1, if $\mathbf{b} = 0$ resp. div $\mathbf{B} = 0$)!

- the current density $\mathbf{j} = -\ \mathbf{v}\ \text{div}\ \mathbf{D} = -\ \mathbf{v} \cdot \rho_{el}$, (3.11)
  (eq. 3.9 ≡ Ampère's law 1.4, if $\mathbf{j}$ ≡ with $\mathbf{v}$ moving negative charge carriers, (ρ_{el} = electric space charge density).

The comparison of coefficients (3.11) in addition delivers a useful explanation to the question, what is meant by the current density $\mathbf{j}$: it is a space charge density ρ_{el} consisting of negative charge carriers, which moves with the velocity **v** for instance through a conductor (in the x-direction).

The current density **j** and the dual potential density **b** mathematically seen at first are nothing but alternative vectors for an abbreviated notation. While for the current density **j** the physical meaning already could be clarified from the comparison with the law of Ampère, the interpretation of the potential density **b** still is due:

$$\mathbf{b} = -\,\mathbf{v}\ \mathrm{div}\ \mathbf{B}\ (=0)\ , \tag{3.10}$$

From the comparison of eq. 3.8 with the law of induction (eq.1.1) we merely infer, that according to the Maxwell theory this term is assumed to be zero. But that is exactly the Maxwell approximation and the restriction with regard to the new and dual field approach, which roots in Faraday.

The Maxwell approximation

In that way also the duality gets lost with the argument that magnetic monopoles (div **B**) in contrast to electric monopoles (div **D**) do not exist and until today could evade every proof. It has not yet been searched for the vortices dual to eddy currents, which are expressed in the neglected term.

Assuming, a monopole concerns a special form of a field vortex, then immediately gets clear, why the search for magnetic poles has to be a dead end and their failure isn't good for a counterargument: The missing electric conductivity in vacuum prevents current densities, eddy currents and the formation of magnetic monopoles. Potential densities and potential vortices however can occur. As a result can without exception only electrically charged particles be found in the vacuum.

Let us record: **Maxwell's field equations can directly be derived from the new dual field approach under a restrictive condition**. Under this condition the two approaches are equivalent and with that also error free. Both follow the textbooks and can so to speak be the textbook opinion.

The restriction (**b** = 0) surely is meaningful and reasonable in all those cases in which the Maxwell theory is successful. It only has an effect in the domain of electrodynamics. Here usually a vector potential A is introduced and by means of the calculation of a complex dielectric constant a loss angle is determined. Mathematically the approach is correct and dielectric losses can be calculated.

Physically however the result is extremely questionable, since as a consequence of a complex ε a complex speed of light would result,

according to the definition: $$c = 1/\sqrt{\varepsilon \cdot \mu} \qquad (3.12).$$

With that electrodynamics offends against all specifications of the textbooks, according to which c is constant and not variable and less then ever complex.

But if the result of the derivation physically is wrong, then something with the approach is wrong, then the fields in the dielectric perhaps have an entirely other nature, then dielectric losses perhaps are vortex losses of potential vortices falling apart?

The magnetic field as a vortex field

Is the introduction of a vector potential **A** in electrodynamics a substitute of neglecting the potential density **b**? Do here two ways mathematically lead to the same result? And what about the physical relevance? After classic electrodynamics being dependent on working with a complex constant of material, in what is buried an insurmountable inner contradiction, the question is asked for the freedom of contradictions of the new approach. At this point the decision will be made, if physics has to make a decision for the more efficient approach, as it always has done when a change of paradigm had to be dealt with.

The abbreviations **j** and **b** are further transformed, at first the current density in Ampère's law

$$\mathbf{j} = -\,\mathbf{v} \cdot \rho_{el} \qquad (3.11)$$

as the movement of negative electric charges.

By means of Ohm's law

$$\mathbf{j} = ((\mathrm{E} \qquad (1.5)$$

and the relation of material

$$D = ((E \tag{1.6}$$

the current density

$$j = D/(1 \tag{3.13}$$

also can be written down as dielectric displacement current with the characteristic relaxation time constant for the eddy currents

$$(1 = (/(\qquad (1.7).$$

In this representation of the law of Ampère:

$$\boxed{\text{curl } H = dD/dt + D/(1 = \varepsilon \cdot (d\mathbf{E}/dt + \mathbf{E}/\tau_1)} \tag{3.14}$$

clearly is brought to light, why the magnetic field is a vortex field, and how the eddy currents produce heat losses depending on the specific electric conductivity σ. As one sees we, with regard to the magnetic field description, move around completely in the framework of textbook physics.

The derivation of the potential vortex

Let us now consider the dual conditions. The comparison of coefficients looked at purely formal, results in a potential density

$$\boxed{\mathbf{b} = \mathbf{B}/\tau_2} \tag{3.15}$$

in duality to the current density **j** (eq. 3.13), which with the help of an appropriate time constant τ_2 founds vortices of the electric field. I call these potential vortices.

$$\boxed{\text{curl } \mathbf{E} = -\, d\mathbf{B}/dt - \mathbf{B}/\tau_2 = -\, \mu \cdot (d\mathbf{H}/dt + \mathbf{H}/\tau_2)} \tag{3.16}$$

In contrast to that the Maxwell theory requires an ***irrotationality of the electric field,*** which is expressed by taking the potential density **b** and the divergence **B** equal to zero. The time constant τ_2 thereby tends towards infinity.

There isn't a way past the potential vortices and the new dual approach,

1. *as the new approach gets along without a postulate, as well as*
2. *consists of accepted physical laws,*
3. *why also all error free derivations are to be accepted,*
4. *no scientist can afford to already exclude a possibly relevant phenomenon in at the approach,*
5. *the Maxwell approximation for it's negligibleness is to examine,*
6. *to which a potential density measuring instrument is necessary, which may not exist according to the Maxwell theory.*

With such a tail-chase always incomplete theories could confirm themselves.

4. Derivation of the wave equation

It has already been shown, as and under which conditions the wave equation from the Maxwell' field equations, limited to transverse wave-portions, is derived (chapter 1.4). Usually one proceeds from the general case of an electrical field strength $\mathbf{E} = \mathbf{E}(\mathbf{r},t)$ and a magnetic field strength $\mathbf{H} = \mathbf{H}(\mathbf{r},t)$. We want to follow this example [18], this time however without neglecting and under consideration of the potential vortex term.

The completed field equations

The two equations of transformation and also the from that derived field equations (3.14 and 3.16) show the two sides of a medal, by mutually describing the relation between the electric and magnetic field strength:

$$\text{curl}\ \mathbf{H} = \partial\mathbf{D}/\partial t + \mathbf{D}/\tau_1 = \varepsilon \cdot (\partial\mathbf{E}/\partial t + \mathbf{E}/\tau_1) \tag{4.1}$$

$$\text{curl}\ \mathbf{E} = -\partial\mathbf{B}/\partial t - \mathbf{B}/\tau_2 = -\mu \cdot (\partial\mathbf{H}/\partial t + \mathbf{H}/\tau_2) \tag{4.2}$$

We get on the track of the meaning of the "medal" itself, by inserting the dually formulated equations into each other. If the calculated **H**-field from one equation is inserted into the other equation then as a result a determining equation for the **E**-field remains. The same vice versa also functions to determine the **H**-field. Since the result formally is identical and merely the **H**-field vector appears at the place of the **E**-field vector and since it equally remains valid for the **B**-, the **D**-field and all other known field factors, the determining equation is more than only a calculation instruction. It reveals a fundamental physical principle. I call it the complete or the "fundamental field equation". The derivation always is the same: If we again apply the curl operation to curl **E** (law of induction 4.2) also the other side of the equation should be subjected to the curl:

$$- \text{curl curl } \mathbf{E} = \mu \cdot \partial(\text{curl } \mathbf{H})/\partial t + (\mu/\tau_2) \cdot (\text{curl } \mathbf{H}) \quad (4.3)$$

If for both terms curl **H** is expressed by Ampère's law 4.1, then in total four terms are formed:

$$- \text{curl curl } \mathbf{E} = \mu \cdot \varepsilon \cdot [\partial^2\mathbf{E}/\partial t^2 + (1/\tau_1) \cdot \partial\mathbf{E}/\partial t + (1/\tau_2) \cdot \partial\mathbf{E}/\partial t + \mathbf{E}/\tau_1\tau_2] \quad (4.4)$$

With the definition for the speed of light c:

$$\boxed{\varepsilon \cdot \mu = 1/c^2,} \quad (1.10)$$

the fundamental field equation reads:

$$\boxed{\underbrace{- c^2 \cdot \text{curl curl } \mathbf{E}}_{a} = \underbrace{\partial^2\mathbf{E}/\partial t^2}_{b} + \underbrace{(1/\tau_1) \cdot \partial\mathbf{E}/\partial t}_{c} + \underbrace{(1/\tau_2) \cdot \partial\mathbf{E}/\partial t}_{d} + \underbrace{\mathbf{E}/\tau_1\tau_2}_{e}} \quad (4.5)$$

(electromagnetic wave) + eddy current + potential vortex + I/U

The four terms are: the wave equation (a-b) with the two damping terms, on the one hand the eddy currents (a-c) and on the other hand the potential vortices (a-d) and as the fourth term the Poisson equation (a-e), which is responsible for the spatial distribution of currents and potentials [21].

A possible world equation

Not in a single textbook a mathematical linking of the Poisson equation with the wave equation can be found, as we here succeed in for the first time. It however is the prerequisite to be able to describe the conversion of an antenna current into electromagnetic waves near a transmitter and equally the inverse process, as it takes place at a receiver. Numerous model concepts, like they have been developed by HF- and EMC-technicians as a help, can be described mathematically correct by the physically founded field equation.

In addition further equations can be derived, for which this until now was supposed to be impossible, like for instance the ***Schrödinger equation*** (Term d and e). As diffusion equation it has the task to mathematically describe field vortices and their structures.

As a consequence of the Maxwell equations in general and specifically the eddy currents (a-c) not being able to form structures, every attempt has to fail, which wants to derive the Schrödinger equation from the Maxwell equations.

The fundamental field equation however contains the newly discovered potential vortices, which owing to their concentration effect (in duality to the skin effect) form spherical structures, for which reason these occur as eigenvalues of the equation. For these eigenvalue-solutions numerous practical measurements are present, which confirm their correctness and with that have probative force with regard to the correctness of the new field approach and the fundamental field equation [21]. By means of the pure formulation in space and time and the interchangeability of the field pointers here a physical principle is described, which fulfills all requirements, which a world equation must meet.

The quantisation of the field

The Maxwell equations are nothing but a special case, which can be derived. (if $1/\tau_2 = 0$). The new approach however, which among others bases on the Faraday-law, is universal and can't be derived on its part. It describes a physical basic principle, the alternating of two dual experience or observation factors, their overlapping and mixing by continually mixing up cause and effect. It is a philosophic approach, free of materialistic or quantum physical concepts of any particles.

Maxwell on the other hand describes without exception the fields of charged particles, the electric field of resting and the magnetic field as a result of moving charges. The charge carriers are postulated for this purpose, so that their origin and their inner structure remain unsettled.

With the field-theoretical approach however the field is the cause for the particles and their measurable quantisation. The electric vortex field, at first source free, is itself forming its field sources in form of potential vortex structures. The formation of charge carriers in this way can be explained and proven mathematically, physically, graphically and experimentally understandable according to the model.

Let us first cast our eyes over the wave propagation.

The mathematical derivation (Laplace eq.)

The first wave description, model for the light theory of Maxwell, was the inhomogeneous Laplace equation (1.12):

$$\Delta \mathbf{E} \cdot c^2 = d^2\mathbf{E}/dt^2$$

with

$$\Delta \mathbf{E} = \text{grad div } \mathbf{E} - \text{curl curl } \mathbf{E} \tag{4.6}$$

There are asked some questions:

- *Can also this mathematical wave description be derived from the new approach?*
- *Is it only a special case and how do the boundary conditions read?*
- *In this case how should it be interpreted physically?*
- *Are new properties present, which can lead to new technologies?*

Starting-point is the fundamental field equation (4.5). We thereby should remember the interchangeability of the field pointers, that the equation doesn't change its form, if it is derived for **H**, for **B**, for **D** or any other field factor instead of for the **E**-field pointer. This time we write it down for the magnetic induction and consider the special case **B**(**r**(t)) [acc. to 19]:

$$-c^2 \cdot \text{curl curl } \mathbf{B} = \frac{d^2\mathbf{B}}{dt^2} + \frac{1}{\tau_2}\frac{d\mathbf{B}}{dt} + \frac{1}{\tau_1}\frac{d\mathbf{B}}{dt} + \frac{\mathbf{B}}{\tau_1\tau_2} \tag{4.7}$$

that we are located in a badly conducting medium, as is usual for the wave propagation in air. But with the electric conductivity σ also $1/\tau_1 = \sigma/\varepsilon$ tends towards zero (eq. 1.7). With that the eddy currents and their damping and other properties disappear from the field equation, what also makes sense.

There remains the potential vortex term $(1/\tau_2) \cdot d\mathbf{B}/dt$, which using the already introduced relations

$$\frac{1}{\tau_2}\frac{d\mathbf{B}}{dt} = \mathbf{v} \text{ grad } \frac{\mathbf{B}}{\tau_2} \tag{3.6}$$

and

$$\frac{\mathbf{B}}{\tau_2} = -\mathbf{v}\ \mathrm{div}\ \mathbf{B} \qquad (3.10+3.15)$$

involved with an in x-direction propagating wave ($\mathbf{v} = (v_x, v_y = 0, v_z = 0)$) can be transformed directly into:

$$(1/\tau_2) \cdot d\mathbf{B}/dt = -\ \|\mathbf{v}\|^2 \cdot \mathrm{grad\ div}\ \mathbf{B}. \qquad (4.8)$$

The divergence of a field vector (div **B**) mathematically seen is a scalar, for which reason this term as part of the wave equation founds so-called "***scalar waves***" and that means that potential vortices, as far as they exist, will appear as a scalar wave. To that extent the derivation prescribes the interpretation.

$$\mathbf{v}^2\ \mathrm{grad\ div}\ \mathbf{B} - c^2\ \mathrm{curl\ curl}\ \mathbf{B} = d^2\mathbf{B}/dt^2 \qquad (4.9)$$

longitudinal with v = arbitrary (scalar wave)	transverse with c = const. (em. wave)	wave velocity of propagation

The simplified field equation (4.7) possesses thus the same force of expression as the general wave equation (4.9), on adjustment of the coordinate system at the speed vector (in x-direction).

The wave equation (4.9) can be divided into longitudinal and transverse wave parts, which however can propagate with different velocity.

The result of the derivation

Physically seen the vortices have particle nature as a consequence of their structure forming property. With that they carry momentum, which puts them in a position to form a longitudinal shock wave similar to a sound wave. If the propagation of the light one time takes place as a wave and another time as a particle, then this simply and solely is a consequence of the wave equation.

Light quanta should be interpreted as evidence for the existence of scalar waves. Here however also occurs the restriction that light always propagates with the speed of light. It concerns the special case v = c. With that the derived wave equation (4.9) changes into the inhomogeneous Laplace equation (4.6).

The electromagnetic wave in general is propagating with c. As a transverse wave the field vectors are standing perpendicular to the direction of propagation. The velocity of propagation therefore is decoupled and constant.

Completely different is the case for the longitudinal wave. Here the propagation takes place in the direction of an oscillating field pointer, so that the phase velocity permanently is changing and merely an average group velocity can be given for the propagation. There exists no restriction for v and v = c only describes a special case.

It will be helpful to draw, for the results won on mathematical way, a graphical model.

5. Field model of waves and vortices

In high-frequency technology is distinguished between the *near-field* and the *far-field*. Both have fundamentally other properties.

The far field (electromagnetic wave acc. to Hertz)

Heinrich Hertz did experiment in the short wave range at wavelengths of some meters. From today's viewpoint his work would rather be assigned the far-field. As a professor in Karlsruhe he had shown that his, the electromagnetic, wave propagates like a light wave and can be refracted and reflected in the same way.

Heinrich Hertz: **electromagnetic wave** (transverse)

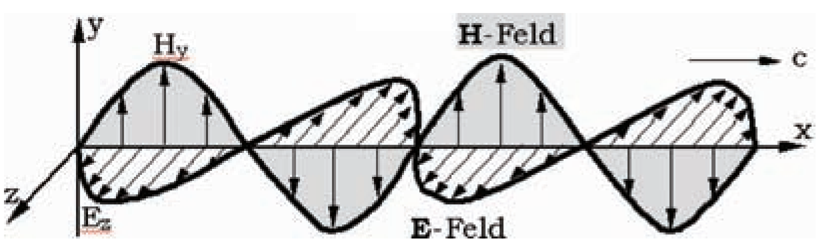

Figure 6. The planar electromagnetic wave in the far zone.

It is a transverse wave for which the field pointers of the electric and the magnetic field oscillate perpendicular to each other and both again perpendicular to the direction of propagation. Besides the propagation with the speed of light also is characteristic that there occurs **no phase shift** between **E**-field and **H**-field.

The near field (Scalar wave acc. to Tesla)

In the proximity it looks completely different. The proximity concerns distances to the transmitter of less than the wavelength divided by 2π. ***Nikola Tesla*** has broadcasted in the range of long waves, around 100 Kilohertz, in which case the wavelength already is several kilometres. For the experiments concerning the resonance of the earth he has operated his transmitter in Colorado Springs at frequencies down to 6 Hertz. Doing so the whole earth moves into the proximity of his transmitter. We probably have to proceed from assumption that the Tesla radiation primarily concerns the proximity, which also is called the radiant range of the transmitting antenna.

For the approach of vortical and closed-loop field structures derivations for the near-field are known [4].

The calculation provides the result that in the proximity of the emitting antenna a phase shift exists between the pointers of the **E**- and the **H**-field. The antenna current and the **H**-field coupled with it lag the **E**-field of the oscillating dipole charges for 90°.

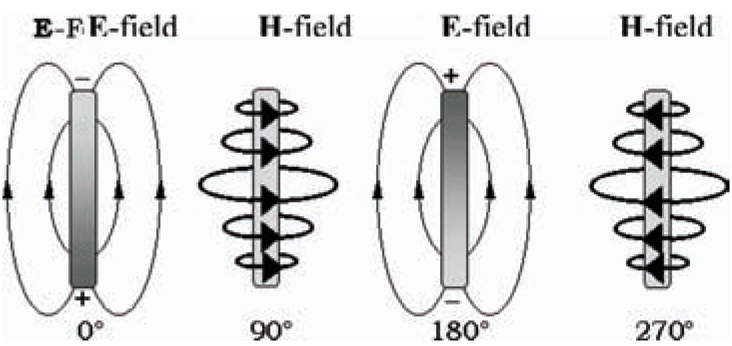

Figure 7. The fields of the oscillating dipole antenna

The near field as a vortex field

In the text books one finds the detachment of a wave from the dipole accordingly explained.

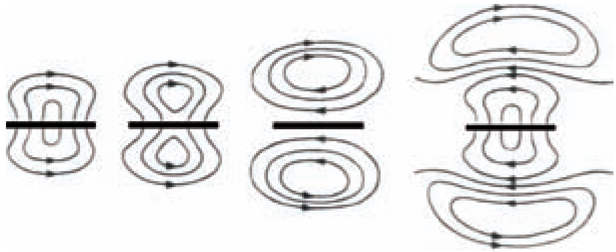

Figure 8. The coming off of the electric field lines from a dipole. The forming vortex structures found a longitudinal electric wave carrying impulse!

If we regard the structure of the outgoing fields, then we see field vortices, which run around one point, which we can call vortex centre. We continue to recognize in the picture, how the generated field structures establish a shock wave, as one vortex knocks against the next [see Tesla: 1].

Thus a Hertzian dipole doesn't emit Hertzian waves! An antenna as near-field without exception emits vortices, which only at the transition to the far-field unwind to electromagnetic waves.

At the receiver the conditions are reversed. Here the wave (a-b in eq. 4.5) is rolling up to a vortex (a-c-d), which usually is called and conceived as a "standing wave". Only this field vortex causes an antenna current (a-e) in the rod, which the receiver afterwards amplifies and utilizes.

The function mode of sending and receiving antennas with the puzzling near field characteristics explain themselves directly from the wave equation (4.5).

The vortex model of the scalar waves

How could a useful vortex-model for the rolling up of waves to vortices look like?

We proceed from an electromagnetic wave, which does not propagate after the retractor procedure any longer straight-lined, but turns instead with the speed of light in circular motion. It also furthermore is transverse, because the field pointers of the **E**-field and the **H**-field oscillate perpendicular to c. By means of the orbit the speed of light c now has become the vortex velocity.

Nikola Tesla: **electric scalar wave** (longitudinal):

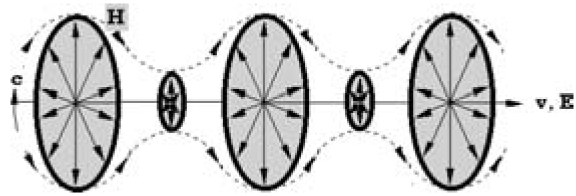

Figure 9. Magnetic ring-vortices form an electric wave.

Wave and **vortex** turn out to be **two** possible and **stable field configurations**. For the transition from one into the other no energy is used; it only is a question of **structure**.

By the circumstance that the vortex direction of the ring-like vortex is determined and the field pointers further are standing perpendicular to it, as well as perpendicular to each other, there result two theoretical formation forms for the scalar wave. In the first case (fig. 9) the vector of the **H**-field points into the direction of the vortex centre and that of the **E**-field axially to the outside. The vortex however will propagate in this direction in space and appear as a scalar wave, so that the propagation of the wave takes place in the direction of the electric field. It may be called an ***electric wave***.

In the second case the field vectors exchange their place. The characteristic of the magnetic wave is that the direction of propagation coincides with the oscillating magnetic field pointer (fig.10), while the electric field pointer rolls up.

magnetic scalar wave (longitudinal):

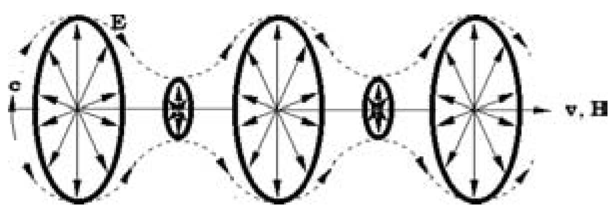

Figure 10. Electric ring-vortices form an magnetic wave.

The vortex picture of the rolled up wave already fits very well, because the propagation of a wave in the direction of its field pointer characterizes a longitudinal wave, because all measurement results are perfectly covered by the vortex model. In the text book of Zinke the near field is by the way computed, as exactly this structure is postulated! [20].

The antenna noise

Longitudinal waves have, as well known, no firm propagation speed. Since they run toward an oscillating field pointer, also the speed vector **v** will oscillate. At so called relativistic speeds within the range of the speed of light the field vortices underlie the **Lorentz contraction**. This means, the faster the oscillating vortex is on it's way, the smaller it becomes. The **vortex constantly changes its diameter** as a impulse-carrying mediator of a scalar wave.

Since it is to concern that vortices are rolled up waves, the vortex speed will still be c, with which the wave runs now around the vortex center in circular motion. Hence it follows that with smaller becoming diameter the wavelength of the vortex likewise decreases, while the natural frequency of the vortex increases accordingly.

If the vortex oscillates in the next instant back, the frequency decreases again. The vortex works as a ***frequency converter!*** The mixture of high frequency signals developed in this way distributed over a broad frequency band, is called ***noise***.

Antenna losses concern the portion of radiated field vortices, which did not unroll themselves as waves, which are measured with the help of wide-band receivers as *antenna noise* and in the case of the vortex decay are responsible for heat development.

Spoken with the fundamental field equation (4.5) it concerns wave damping. The wave equation (4.9) explains besides, why a Hertz signal is to be only received, if it exceeds the scalar noise vortices in amplitude.

6. Summary

The proof could be furnished that within the Maxwell field equations an approximation lies buried and they only represent the special case of a new, dual formulated more universal approach. The mathematical derivations of the Maxwell field and the wave equation uncover, wherein the Maxwell approximation lies. The contracting antivortex dual to the expanding vortex current with its skin effect is neglected, which is called potential vortex. It is capable of a structural formation and spreads in badly conductive media as in air or in the vacuum as a scalar wave in longitudinal way.

At relativistic speeds the potential vortices underlie the Lorentz contraction. Since for scalar waves the propagation occurs longitudinally in the direction of an oscillating field pointer, the potential vortices experience a constant oscillation of size as a result of the oscillating propagation. If one understands the field vortex as an even however rolled up transverse wave, then thus size and wave-length oscillation at constant swirl velocity with c follows a continual change in frequency, which is measured as a noise signal.

The noise proves as the potential vortex term neglected in the Maxwell equations. If e.g. with antennas a noise signal is measured, then this proves the existence of potential vortices. However if the range of validity of the Maxwell theory is left, misinterpretations and an excluding of appropriate phenomena from the field theory are the consequence, the noise or the near field cannot be computed any longer or conclusively explained.

View on the technical solution

If the antenna efficiency is very badly, for example with false adapted antennas, then the utilizable level sinks, while the antenna noise increases at the same time.

The wave equation following the explanation could also read differently: From the radiated waves the transversals decrease debited to the longitudinal wave components. The latter's are used however in the transponder technology as sources of energy, why unorthodox antenna structures make frequently better results possible, than usual or proven.

Ball antennas proved in this connection as particularly favourable constructions. The more largely the ball is selected, the more can the reception range for energy beyond that of the near field be expanded. This effect can be validated in the experiment.

So far high frequency technicians were concerned only with the maximization of the transversal utilizable wave, so that this does not go down regarding the noise. The construction of far range transponders however require false adapted antennas, the exact opposite of what is learned and taught so far in the HF technology, inverse engineers and engineering so to speak. And in such a way the introduction and development of a new technology requires first an extended view and new ways of training.

7. Table of formula symbols

Electric field			Magnetic field		
E	V/m	Electric field strength	**H**	A/m	Magnetic field strength
D	As/m^2	Electric displacement	**B**	Vs/m^2	Flux density
U	V	Tension voltage	I	A	Current
b	V/m^2	potential density	**j**	A/m^2	Current density
ε	As/Vm	Dielectricity	μ	Vs/Am	Permeability
Q	As	Charge	ϕ	Vs	Magnetic flux
e	As	Elementary charge	m	kg	Mass
τ_2	s	Relaxation time constant of the potential vortices	τ_1	s	Relaxation time constant of the eddy currents

Other symbols and Definitions:			
Specific electric conductivity		σ	Vm/A
Electric space charge density		ρ_{el}	As/m^3
Dielectricity	$\varepsilon =$	$\varepsilon_r \cdot \varepsilon_o$	As/Vm
Permeability	$\mu =$	$\mu_r . \mu$	Vs/Am
Speed of light	$c =$	$1/\sqrt{\varepsilon \cdot \mu}$	m/s
Speed of light in a vacuum	$c_o =$	$1/\sqrt{\varepsilon_0 \cdot \mu_0}$	m/s
Time constant of eddy currents	$\tau_1 =$	ε/σ	s
Concerning vector analysis: **Bold print** = field pointer			

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Appendix

More than 100 Years ago ***Nikola Tesla*** has demonstrated three versions of *transportation electrical energy*:

1. *the 3-phase-Network, as it is used today,*
2. *the one-wire-system with no losses and*
3. *the magnifying Transmitter for wireless supply.*

The main subject of the conference presentation will be the wireless system and the practical use of it as a far range transponder (RFID for large distances). Let me explain some expressions as used in the paper.

A "**scalar wave**" spreads like every wave directed, but it consists of physical particles or formations, which represent for their part scalar sizes. Therefore the name, which is avoided by some critics or is even disparaged, because of the apparent contradiction in the designation, which makes believe the wave is not directional, which does not apply however.

The term "**scalar wave**" originates from mathematics and is as old as the wave equation itself, which again goes back on the mathematician Laplace. It can be used favourably as generic term for a large group of wave features, e.g. for acoustic waves, gravitational waves or plasma waves.

Seen from the physical characteristics they are longitudinal waves. Contrary to the transverse waves, for example the electromagnetic waves, scalar waves carry and transport energy and impulse. Thus one of the tasks of **scalar wave transponders** is fulfilled.

The term "**transponder**" consists of the terms transmitter and responder, describes thus radio devices which receive incoming signals, in order to redirect or answer to them. First there were only active transponders, which are dependent on a power supply from outside. For some time passive systems were developed in addition, whose receiver gets the necessary energy at the same time conveyed by the transmitter wirelessly.

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Modulation of Ultrasonic Signal in Vortex Street of Fluids

Abstract

Vortex flow meters belong in a class of the new technology flow meters as: magnetic, ultrasonic, carioles and thermal flow meters. But, although, vortex flow meters are based on relatively simple phenomenon, explained more then 80 years ago by von Karman, their application at the last two decades have not been so significant like other flow meters of new technology. There are tow reasons for that.

Other new technology flow meters have better accuracy and no pressure loss on the meter. According to general opinion, the growth of application of vortex flow meters in future will depend on improvement of those two characteristics.

In this paper, reduction of size of the bluff body will be analyzed. Results of experimental tests of vortex flow meter for liquid fluid, in the five different shapes of bluff body, each of them with five different characteristic of size will be presented.

For this search, prototype of vortex flow meter (PVMP50), DN 50 mm for liquid fluid, based on amplitude and phase modulations of ultrasonic wave have been developed.

Key words

Flow meters of new technology, vortex flow meter, vortex street, bluff body, vortices, ultrasonic wave, modulation signal.

Introduction

Vortex flow meter is based on Von Karman vortex street phenomenon. The frequency of vortices, separated on the bluff body, depends nearly linearly on the mean flow velocity. Relation between the vortex frequency *f*, the mean flow velocity v and the diameter (characteristic size) of the bluff body d is expressed by the dimensionless form known as Strouhol number S_t:

$$S_t = \frac{fd}{v} \Rightarrow v = kf, \text{ where is } k = \frac{d}{S_g} \tag{1}$$

Scheme of vortex street, behind the bluff body is presented in the figure 1.

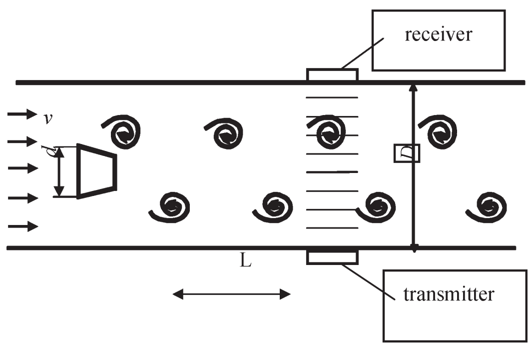


Figure 1. Vortex street behind the bluff body

Separation of vortices causes changes of pressure in the vortex street. First method for their detection used pressure sensors, placed inside the pipe, or inside the bluff body. Most commercial vortex meters are based on this method of vortices detection. Sensitivity and rangebility of pressure sensor require strong vortices. It means using large bluff body, size 25% – 30% of pipe diameter. But, large bluff body makes significant pressure loss on the vortex flow meter.

Using ultrasound for detection of vortices in vortex street opens new possibility in that way. Modulation of ultrasonic beam (amplitude and phase) in vortex street is much more sensitive phenomenon than changes in pressure, and it is possible to detect smaller and weaker vortices. It means possibility to reduce characteristic dimension of bluff body of vortex flow meter, for liquid and gas fluid, and at the same time to reduce pressure loss on the meter.

2. Method of measurement by ultrasound

Analysis of propagation of ultrasonic wave through the von Karman vortex street, prependicular to the axis of the pipe and bluff body will be presented, assuming that the following conditions are sattisfied:

- the flow is two-dimensional,
- vortices are circular in shape,
- the flow is potential in vortices and turbulent outside of the vortices,
- the shape of vortices does not change in stable flow region,
- von Karman vortex street is unlimited and vortices are generated from both sides of the bluff body and have the same value of circulation, but opposite direction.

Ampilitude and phase modulation of the ultrasonic wave are result of interaction between two mechanical fields (flow velocity field and ultrasonic field): We will consider motion of the wave in 2D (x-y) plane as shown in fig 1.

Equation describing ultrasonic wave propagation through the fluid flow can be written as:

$$\Delta u - \frac{1}{c^2} \cdot \frac{\partial^2 u}{\partial t^2} = 0, \tag{3}$$

where Δ is Laplace operator.

Ultrasonic wave propagates only to y direction (fig.1.), so relation (3) becomes:

$$\frac{\partial^2 u}{\partial y^2} - \frac{1}{c^2} \cdot \frac{\partial^2 u}{\partial t^2} = 0$$

Solution of this eqation is harmonic function, that can be written:

$$u(y,t) = U(y) \cdot \cos(\omega_0 t - k_y + \varphi_0) \tag{4}$$

where are:

ω_0 – ultrasonic circular freqency, $\omega_0 = 2\pi f_0$

k – wave number, $|k| = \dfrac{2\pi}{\lambda} = \dfrac{2\pi f_0}{c}$,

φ_0 – initial phase angle of ultrasonic wave, Amplutide of the ultrasonic wave $U(y)$ is a function of distance from ultrasonic transmitter and absorption coefficient of ultrasonic wave in liquid.

$$U(t) = U_0 \cdot e^{-my}$$

where m is absorption coefficient.

Ultrasonic signal on the transmitting side where $y = 0$ is:

$$U(t) = U_0 \cdot \cos(\omega_0 t + \varphi_0),$$

and on the receiving side where ($y = D$):

$$U(t) = U_0 \cdot e^{-mD} \cdot \cos(\omega_0 t - k_D + \varphi_0).$$

When ultrasonic wave passes trough the vortices, relation (4) could be written as:

$$u(y,t) = U_0 \cdot e^{-m(c \pm V_\theta)t} \cdot \mathrm{Re}\lfloor e^{j\phi(t)} \rfloor$$

$$\phi(t) = \omega \cdot t - ky + \varphi_0$$

On the receiving side this equation becomes:

$$u(y,t) = U_0 \cdot e^{-mD} \cdot e^{\pm\frac{mV_{ej} \cdot D}{c}} \cdot \mathrm{Re}\lfloor e^{j\phi(t)} \rfloor, \tag{5}$$

Expression $U = U_0 \cdot e^{-mD}$ is a result of absorption of ultrasonic wave on the receiving side,

in fluid free from the vortices in the street. Relation (5) becomes:

$$u(y,t) = U_1 \cdot e^{\pm\frac{mV_{ej} \cdot D}{c}} \cdot \mathrm{Re}\left[e^{j\varphi(t)}\right] \tag{6}$$

Factor $e^{\pm\frac{mV_{ej} \cdot D}{c}}$ shows effect of influence of vortices to amplitude of the ultrasonic wave.

It is a result of absorption of ultrasonic wave in the vortices and their tangential velocity.

If we expand $e^{\pm\frac{mV_{ej}\cdot D}{c}}$ in the Taylor series and take first two terms we will get:

$$u(y,t) = U_1 \cdot \left(1 \pm \frac{mD}{c} \cdot V_{\theta y} \cdot \cos\omega \cdot t\right) \mathrm{Re}\left[e^{j\varphi(t)}\right] \quad (7)$$

where: $V_{\theta y} = V_\theta \cdot \cos\varphi \cdot t$,

Sign ± indicates opposite direction of velocity circulation of generated vortices.

Denoting $m_a = \pm\frac{mDV_\theta}{c}$ expression (7) becomes:

$$u(y,t) = U_1 \cdot (1 \pm m_a \cdot \cos\omega \cdot t) \cdot \mathrm{Re}\left[e^{j\phi(t)}\right] \quad (8)$$

Equation (8) presents well known amplitude modulated signal where m_a is coefficient of modulation.

According to relation (4) we can consider that $\varphi_0=0$ (without any decrease in generality), so the phase of wave is given by:

$$\Phi(t) = \omega_0 t - \frac{2\pi f_0}{c} \cdot y.$$

For homogeneous liquid fluid $y = \pm\frac{D}{c}V_{\Theta y}$, i.e. $y = \pm\frac{D}{c}V_\Theta \cos\omega t$ where:

ω – angular frequency,

$V_{\Theta y}$ – y component of tangential velocity.

Sign ± indicates opposite direction of velocity circulation of generated vortices on different sides of the vortex shedder.

Finally, modulated signal on the receiving side can be written as follows:

$$U(D,t) = [U_0(1 + m_a \cos\omega t)] \cdot \cos(\omega_0 t + m_p \cos\omega t) \quad (9)$$

where are:

m_a – coefficient of amplitude modulation, $m_a \sim \dfrac{m \cdot F \cdot V_\theta}{c}$,

m_p – coefficient of phase modulation, $m_p \sim \dfrac{4\pi f_0 D V_\theta}{c^2}$,

c – velocity of ultrasound in liquid,

f_0 – frequency of ultrasonic signal, $f_0 = \dfrac{\omega_0}{2\pi}$

Both phase and amplitude modulation of the ultrasonic signal are happening at the same time.

Modulation of ultrasonic wave is a result of interaction between the fluidic and ultrasonic field. Amplitude and phase modulation are happening at the same time. For cylindrical shape of vortices and infinite vortex street, amplitude and phase modulation of ultrasonic wave can be described by relation (9).

According to the relation (9), intensity of the tangential velocity of vortices is the key parameter witch affects to coefficient of amplitude and phase modulation of ultrasonic wave, for constant resonant frequency of ultrasonic transducer. Tangential velocity of vortices affects on modulation of ultrasonic wave more than changes of pressure in vortex street, and it is possible to detect vortices smaller and weaker than usually. This possibility provides reduction of characteristic dimension of bluff body and at the same time reduction of pressure loss on the meter.

3. Experimental results

For approving possibility to use vortex flow meter, with smaller size of bluff body then “standard”, a prototype ultrasonic vortex flow meter PVMP50, DN 50mm was developed. Testing and calibration prototype vortex flow meter were realized by “Water calibration station”. Turbine flow meter size 50mm, has been used as a standard flow meter, witch uncertainty was ±0,15%. Testing of prototype PVMP50, with five different shapes of bluff body (cylindrical, triangular, trapezoid, rectangular and half cylindrical), each of them with five characteristic dimensions (3mm, 5mm, 7mm, 9mm and 12mm), has been realized.

Demodulation signal as results of testing of prototype vortex flow meter, with bluff body in five different shapes, (cylindrical, triangular, trapezoid, rectangular and half cylindrical), each of them size 3mm, are shoved in the figures 2. to 6. respectively. Values of Strouhal number and frequency of measurement signal at flow rate [200 l/min] has been presented in the table 1. Maximal flow rate was 250 [l/min] and is limited by pump and capacity of pull, not by flow rate of flow meter. It does not affect general conclusions, because vortex flow meter has good linearity at high flow rate (less then 0,75%).

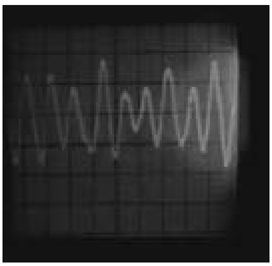
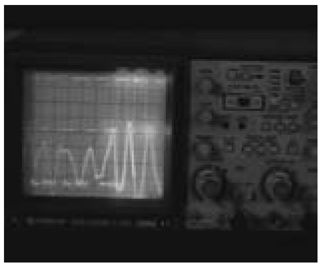


Figure 2.



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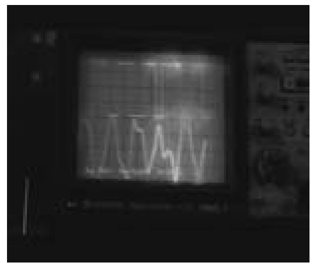
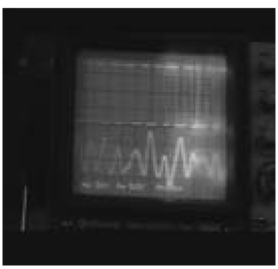


Figure 4.



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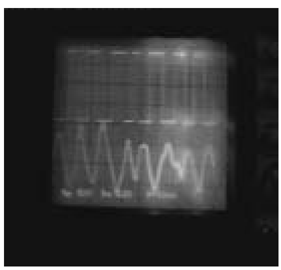

Figure 6.

Table 1.

No	shape of bluff body	size	flow [l/min]	f [Hz]	S_h
1.	cylindrical	3mm	200	128	0,226
2.	triangle	3mm	200	144,8	0,256
3.	trapezoid	3mm	200	148,6	0,262
4.	rectangle	3mm	200	138,8	0,245
5.	half cylin.	3mm	200	126,8	0,224

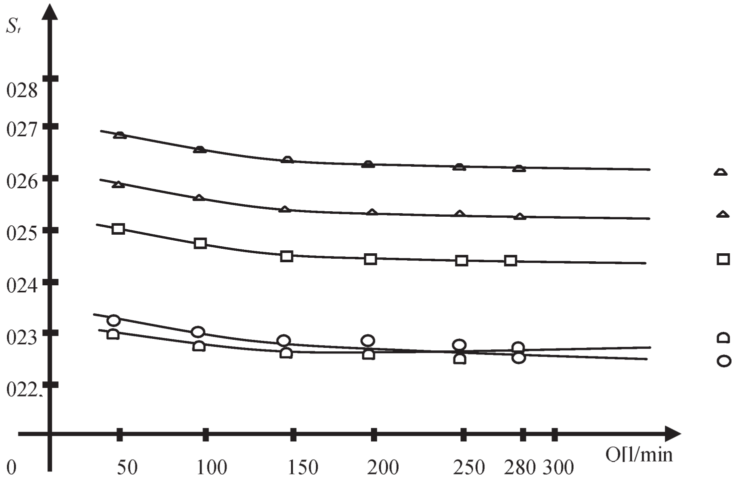

Figure 7. Strouhal number for different shapes of bluff body

Strouhal number for different shapes of bluff body, with same characteristic dimension, (size 3mm), has been presented in the fig. 7. The best linearity has been achieved using cylindrical shape of the bluff body. It was first reason to use this shape of bluff body for next step of testing and calibration.

Possibility to avoid increase of uncertainty cased by its fitting on in body of flow meter was a second reason.

Results of testing of prototype vortex flow meter, and form of measurement (demodulated) signal in time domain, for cylindrical bluff body, with five different characteristic dimensions (3mm, 5mm, 7mm 9mm and 12 mm) have been done in the figures 2;7; 8; 9 and 10 respectively. Level of measurement signal is higher for larger characteristic dimension of bluff body. It was expected, because it is the result of rising of vortices. Flow rate was same in every noticed case, and it's amount [200 l/min].

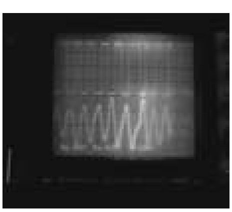

Figure 8.

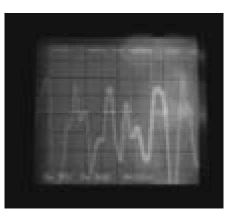

Figure 9.

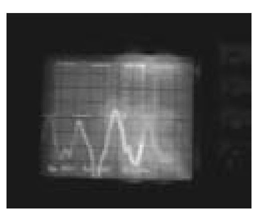

Figure 10.

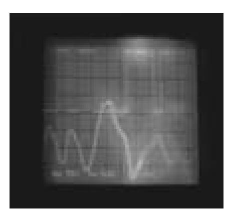

Figure 11.

Characteristic flow parameters were presented in table 2.

Table 2.

num.	shape of bluff body	size	flow [l/min]	f [Hz]	S_h
1.	cylindrical	3mm	200	128	0,226
2.	cylindrical	5mm	200	77,4	0,228
3.	cylindrical	7mm	200	56	0,231
4.	cylindrical	9mm	200	44	0,233
5.	cylindrical	11mm	200	36,4	0,236

4. Calibration of prototype vortex flow meter PVMP50

Calibration of prototype vortex flow meter PVMP50 with cylindrical shape of bluff body, size 3mm has been realized by “Water calibration station,,. Turbine flow meter, which uncertainty was 0,15%, has been used like standard flow meter. Prototype and turbine flow meter have been connected in a line. Water passes trough the standard flow meter, and after through the calibrated (vortex) flow meter. Plane part of the tube, in front of the prototype flow meter was 40D.

Flow rate has been tuned by the regulation valve, placed between the standard and calibrated meter.

Results of calibration are presented in the table 3. and fig 12.

Num.	Shape of bluff body	Charac. dimension	*Flow* Q[l/min]	*Velocity* v[m/s]	R_e	f [Hz]	S_h
1.	Cylindrical	$d = 3$ mm	50,5	0,429	$2,1 \cdot 10^4$	32,6	0,228
2.			100,2	0,851	$4,3 \cdot 10^4$	64	0,226
3.			151	1,28	$6,4 \cdot 10^4$	76	0,225
4.			200,8	1,705	$8,5 \cdot 10^4$	128	0,225
5.			250,6	2,13	$1,1 \cdot 10^5$	160	0,2256
6.			280,5	2,38	$1,2 \cdot 10^5$	179,0	0,2257

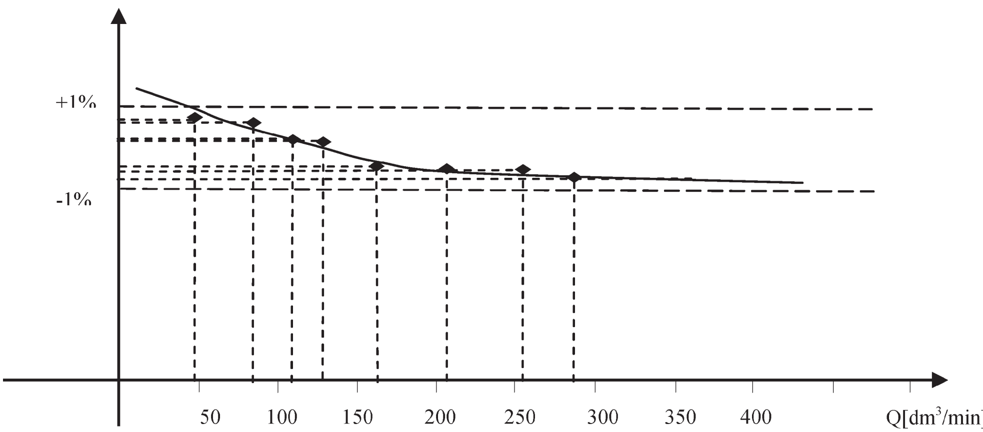

Figure 12. Calibration curve of prototype vortex flow meter PVMP50

Calibration constant could be determined by following relation: $K_V = \frac{N_v}{V_r}$ where are:

N_v – registered impulses on the counter of calibrated (vortex) flow meter at the fixed time interval,

V_r – volume of flow trough the standard flow meter at the same time. Maximal flow rate has been limited by capacity of installation (280 [l/min]).

5. Conclusion

Ultrasonic detection of vortices offers new possibility regarding characteristic size of bluff body. Amplitude and phase modulation of ultrasonic wave in vortex street are, first of all results of interaction between fluid and ultrasonic velocity field [1], [2].

Results of calibration approved advantages of vortex flow meter based on ultrasonic detection of vortices concerning on size of bluff body and pressure loss on the meter, and offers next conclusions:

1. linearity of calibration curve, in all of the flow rate is better then ±1%,
2. minimal flow rate detected by prototype vortex flow meter was less then 50 [l/min],
3. minimal mean velocity was 0.43 [m/s],
4. corresponded Reynolds number was $2.1 \cdot 10^{4}$.

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Tesla's High Frequency Currents in Electrotherapy

Abstract

Tesla's ways of producing high-frequency currents from the inductive generator to the sparkling oscillator are shown. His experiments with high-frequency currents and their demonstration in electric fields phenomena at public presentations, in expert articles and with patent registrations are being considered.

Denotations by Tesla about the possibility of warming the human body are also analyzed. The devices for electrotherapy are described that follow Tesla's experiments as well as electrotherapy procedures in the first decades of the 20th century by relying upon the literature of that time.

Particular contemporary electrotherapy devices and procedures are being studied based on the experiences in the application of Tesla's high-frequency currents.

Moreover the names of particular electrotherapy devices and procedures are compared, those that follow Tesla's experiments with high-frequency currents applied on live tissue, as well as the frequent omission of Tesla's contribution without any reason. The citations of Tesla's contribution to electrotherapy in dictionaries, lexicons and encyclopaedias are also being considered.

Key words

Tesla's currents, Tesla's transformer, electrotherapy, teslinization, d'arsonvalization

Passage towards high frequency currents

Tesla's numerous inventions and patents are first of all connected to alternating currents for energy and signal transfer. It is seldom mentioned that Nikola Tesla applied alternating currents not only to start the electric motors but also to supply power for lighting fixtures. At the very beginning of electric energy application it was used primarily for illumination. It was the era when electric lamps consisted of weak and short-lasting light bulbs with a coal thread while for stronger lighting fixtures there used to be rather clumsy and noisy electric arc lamps not easy to handle. After a short activity within an Edison's firm, in 1885 Tesla founded his own one *Tesla Electric Light and Manufacturing Company* for electric arc lamps manufacturing, which was something he was immediately able to sell on the market.

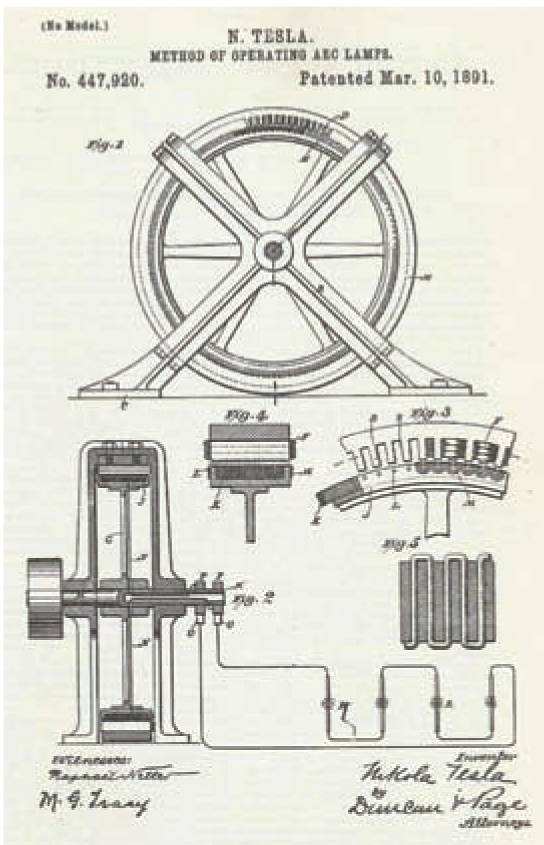


Figure 1. Patent sketch of Tesla's high frequency induction generator

Soon he found out that the arc lamps were functioning more calmly and with less noise in case they were fed with higher frequency currents, first those of several hundred hertz (Hz). For this reason in the 1880-s Tesla constructed induction generators with always higher frequency, first hundreds of hertz and later thousands of hertz. The frequency of induction generators was at the beginning for mechanical reasons not stabile and limited to 10 kHz at the most, depending of mechanical conditions in which the generator was turning round. And Tesla described it as a major hindrance for the instrument functioning at high frequencies.

Switchover to sparkling oscillators

In 1889, for reasons of instability and frequency limitations of induction generators, Tesla switched to the sparkling oscillator as a high-frequency source. He relied on lord Kelvin's experiments of 1856 with a condenser emptying, and probably also on the sparkling oscillator applied by Heinrich Hertz in his famous electromagnetic waves experiments of 1887/88.

Tesla was achieving stabile and significantly higher frequencies with his sparkling oscillator, but with the application of his high frequency transformer *(Tesla's transformer)* he achieved even significantly higher voltages than the ones attained by the induction generator.

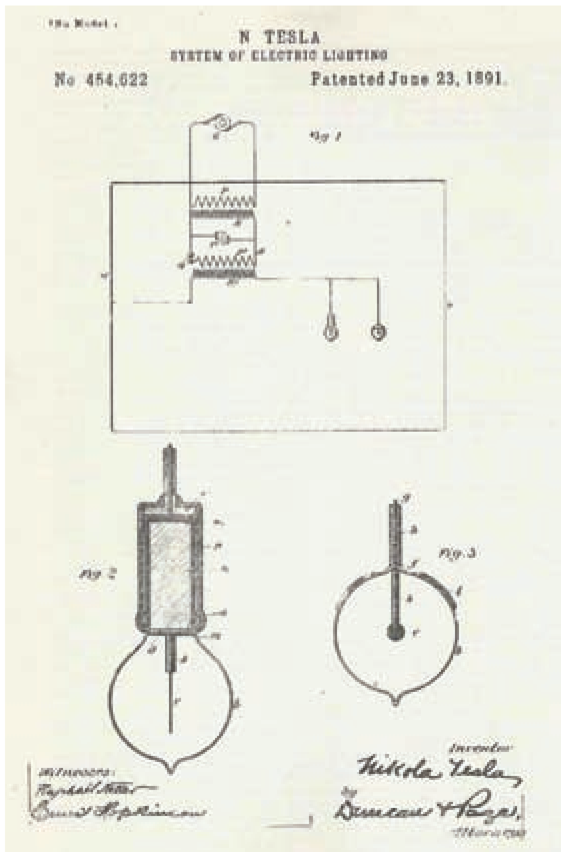


Figure 2. Patent sketch of feeding illumination valves by a sparkling oscillator and high frequency transformer (*Tesla's transformer)*

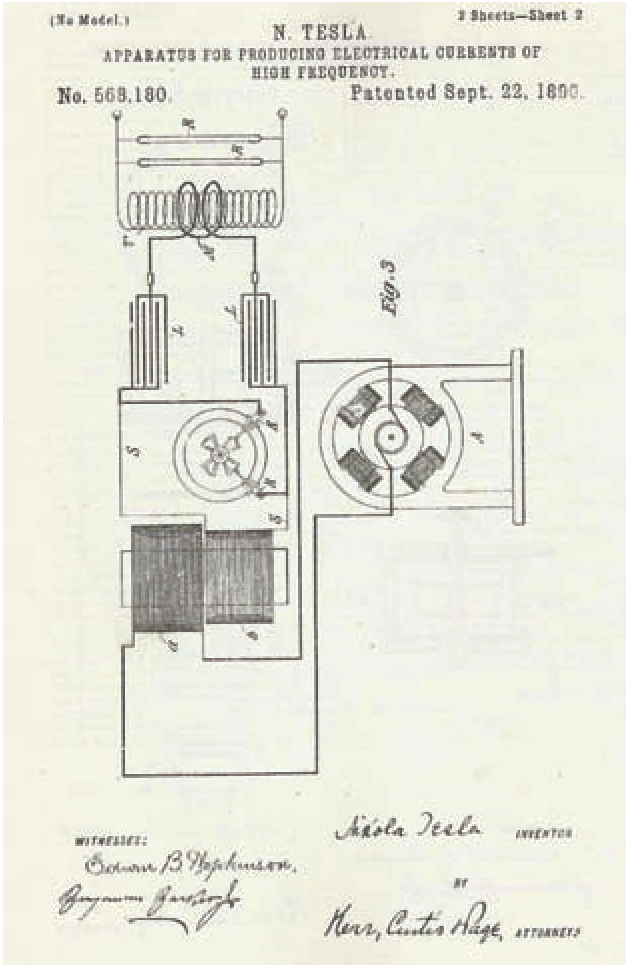


Figure 3. Patent sketch of Tesla's high frequency rotating sparkling oscillator and transformer *(Tesla's transformer)*

Phenomena in high frequency fields and *Tesla's currents*

In his experiments with high frequency currents that were first meant for feeding electric lighting fixtures and illumination valves Tesla noticed numerous unusual phenomena.

He first established that in fields produced by high frequency currents illumination valves were working without being directly switched in the galvanic current circuit. Further on, although it had been previously known that high-frequency currents provoke only a warming effect in living tissues, in his experiments Tesla found out first on himself and later on his laboratory visitors that one could be exposed to high frequencies without any danger. In such experiments there was a strong spark emitting on the contact spots and the illumination valves were lighting in the electric field although not directly connected to the current circle. Those impressing experiments were also demonstrated during his public lectures.

For those reasons the high frequency currents started being publicly called *Tesla's currents* at the beginning of the 1980-s. During his lectures and in his written reports Nikola Tesla announced that high frequency currents would meet a great public interest and expectations, so that even the newspapers in 1899 published the sensational news, e.g. that Nikola Tesla was curing a widely spread and evil illness of the time – lung tuberculosis – by means of high frequency currents.

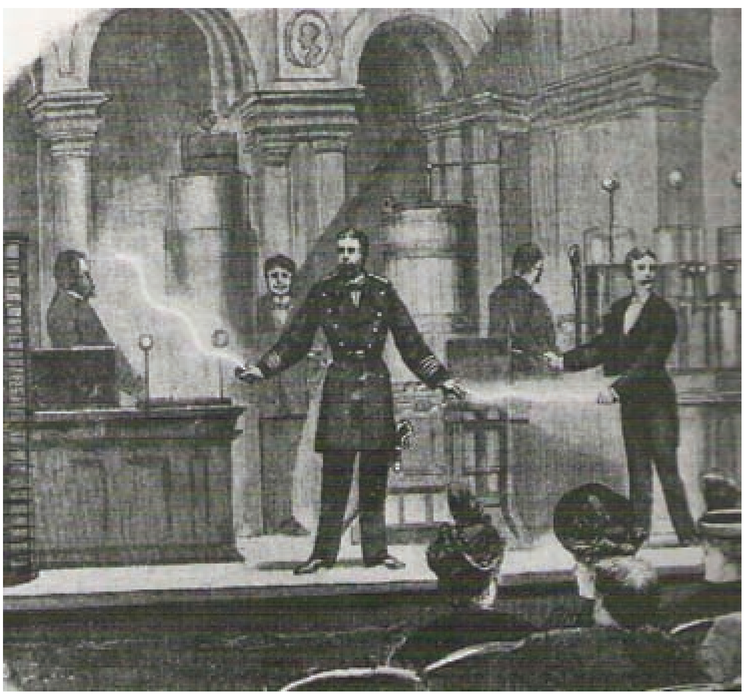


Figure 4. Public experiment of Tesla's "future illumination" in Berlin, 1895 and prince Heinrich "closing" a high frequency current circle in such a way that illumination valves are lighting in their hands (Feldman and Ford 1979)

Tesla's powerful instruments

In order to grasp Tesla's experiments one should notice that he was working with rather high voltages (million volts value), very strong currents (hundred amperes) and very high frequencies (in hundreds of kilohertz or megahertz).

It's interesting to mention that Oton Kučera, a great promoter of natural sciences and technical inventions of the time, already in 1902 wrote almost enthusiastically (Kučera, 1902), (Kučera, 1903):

" ……. *the whole world is viewing this Croatian son Nikola Tesla, who is dealing with research in nature across the ocean. The research is about the fact that electric voltages in vertical wires are increased as much as possible. Whatever Europe is using and doing in that direction practically disappears when opposed to Tesla's results. The sparkles he obtains in his artificial manner are true giants compared to European sparkles, "it is more", as Slaby puts it, "than our most brave imagination is allowed to dream of."*

Nikola Tesla and his lectures

In his numerous public lectures Nikola Tesla gave an extensive presentation of his experiments with high frequency currents, and specially well and extensively in his lecture for the *American Electro-Therapeutic Association* (Buffalo, 13th-15th September, 1898) entitled *High-Frequency Oscillators for Electro Therapeutical and Other Applications.* (Tesla 1898)

In that lecture Tesla clearly limited himself to research of the effects on living tissues but left their curing use to medical staff. In the lecture he strictly determined "while the physician is left with the research of the influence on organisms and investigation of appropriate curing procedures, the technician is given the task to research different application manners of applying those currents to the patient's body." The paper published about that lecture contained Tesla's original sparkling oscillator sketches for the electro-physiologic experiments.

Within the work Tesla described the devices, experiments and their function in detail. What is specially important in medical application of high frequency currents Tesla clearly described the **ways of connecting** a

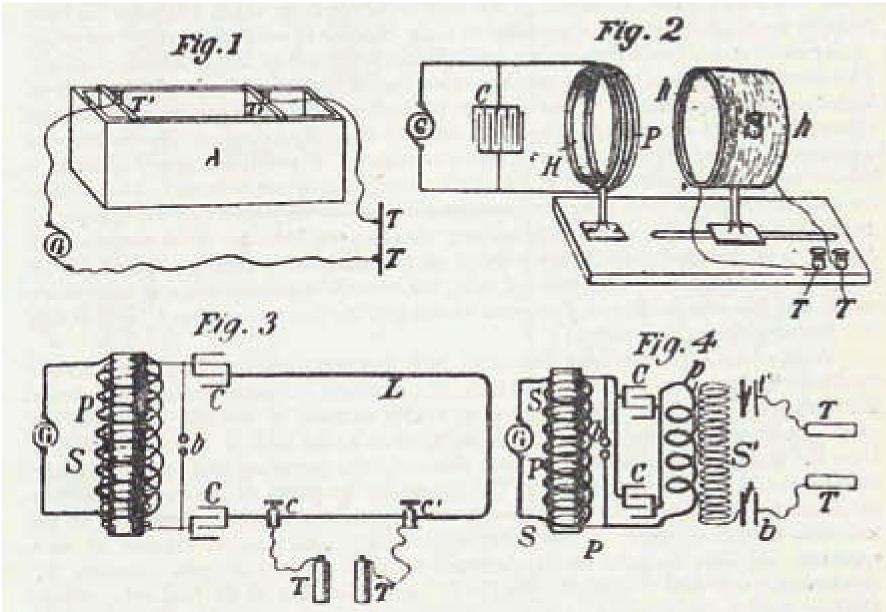


Figure 5. Tesla's original sketches of a sparkling oscillator for electro-physiologic experiments; T-T are electrodes for inclusion of tissue or organism

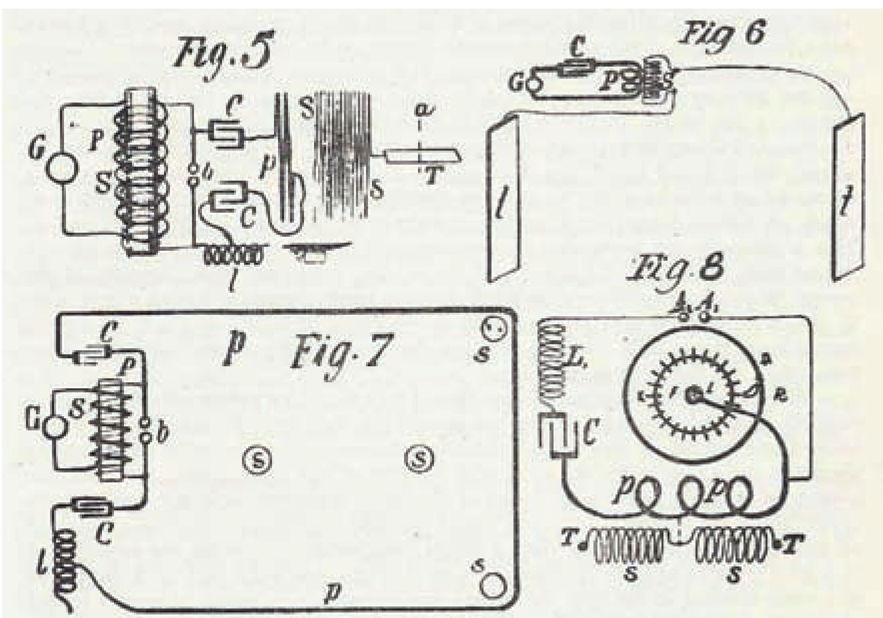


Figure 6. Tesla's original sketches of a sparkling oscillator for electro-physiologic experiments; T-T are condenser plates for the creation of an electric field

living tissue or organism, and **control** those instruments. They have so far been the basic procedures in the therapeutic application of high frequency currents.

Electrotherapy with alternating currents

Alternating currents electrotherapy started in the middle of the 19th century with an application of Ruhmkorff's electromechanic inductor (in 1851). As the inductor was based on Faraday's electromagnetic induction the series of impulses was called *Faraday's currents* and the therapeutic procedure was known as *Faradization*. Faradic currents stimulated nerves and which was a form of *electric stimulation*.

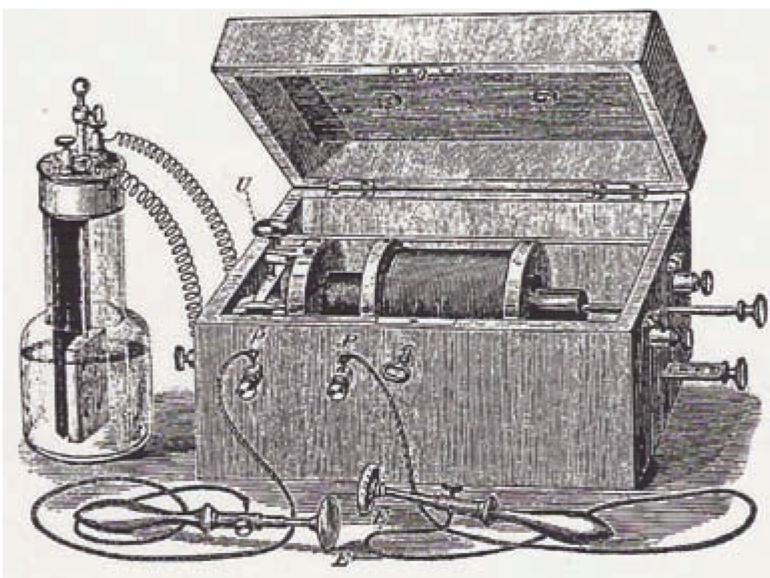


Figure 7. Ruhmkorff's inductor for medical application (in the 1880-s)

Therapy with Tesla's currents

In primary therapeutic applications of Tesla's currents the patients were connected to the current circuit in several ways, that can be defined as directly connecting a patient into the circuit or including a patient into the field.

The patient is directly connected into the circuit by *special electrodes (conducting brush)* or by *glass tubes* filled with gas under low pressure.

The patient is included into the electric field among two, mostly plate-like electrodes, within or very close to the coil.

Teslinization or d'Arsonvalization

Therapeutic procedures by *Tesla's currents* were called

- **Teslinization** after Nikola Tesla, or
- **d'Arsonvalization** or **Arsovalization** after a French physiologist and physician Jacques-Arsen d'Arsonval (1851 – 1940).

In expert circles is frequently a doubt about whether they are two different therapeutic procedures or else just two expressions for the same therapeutic procedure.

The answers can be found in the literature about the first among Tesla's currents application in electrotherapy. Tesla, the technician investigated the phenomena caused by high frequency currents and constructed excellent instruments noticing their physiologic effects. He demonstrated them all in public and subsequently patented them. A medical doctor d'Arsonval applied those high frequency currents in electrotherapy.

Tesla and d'Arsonval had met in Paris on an occasion of Tesla's lectures in Europe in 1892. Tesla was very pleased to find out that d'Arsonval was using his oscillator in researching the physiological effects of high frequency currents.

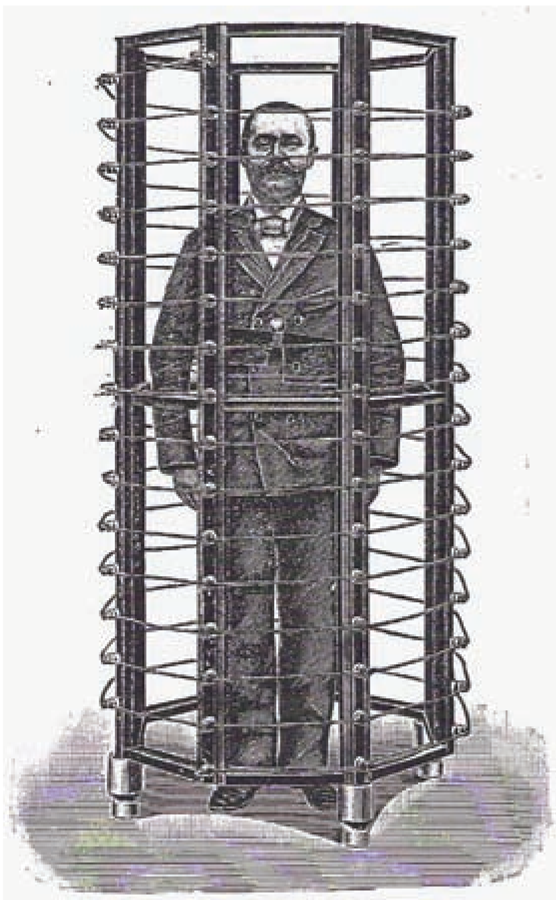
The first medical institution applying high frequency currents was established by d'Arsonval in 1895 at *Hotel-Dieu Hospital* in Paris.

The name *d'Arsonvalization* for applying high frequency currents in electrotherapy appeared only after several years of use. It was suggested by the Austrian neurologist Moritz Benedikt in 1899.

In the literature of the time there are undoubted data about the fact that d'Arsonvalization is actually an application of Tesla's currents in electrotherapy.

"The doubts about the priority of either Tesla or d'Arsonval dates back to the time when d'Arsonval published his first article in February 1891 and Tesla on 23rd May in the same year. Tesla's instruments were more powerful than those of d'Arsonval." (*Tesla or d'Arsonval?* Arch. Phys. Ther., 19:108, 1937.). (Licht 1965)

In the *Book of Inventions, Trades and Industry* of 1898, there was an illustration photo with a signature "d'Arsonval's experiment about physiologic effect of Tesla's currents" (Fig. 8). (Das Buch der Erfindungen 1898)



803. d'Arsonvals Versuch über die physiologische Wirkung der Teslaströme.

Figure 8. Illustration of "*d'Arsonval's experiment about the physiologic effect of Tesla's currents*" in 1899.

In a monograph named *The Bases of Practical Electrotherapy* which was a classical work on electrotherapy used by generations of electro-physiatrists, electrotherapists and medical physicists one can find clear statements (Meyer 1939):

"*High-frequency currents created in such a way were called after their inventor Tesla's currents. Their medical application is called Arsonvalization (after the French physiologist d'Arsonval),"*

"Tesla's currents are therapeutically applied for general and localized treatment."

"Tesla's currents in Arsonvalization achieved with high power currents have a certain faradic effect and a slow warming influence."

In another classic title *Physical Medicine in Diagnostics and Therapy* of 1940 (Holzer 1949) there was an interesting illustration of an instrument and the application of *d'Arsovalization,* where you can see an obvious signature in German "*Tesla's primar coil*" and "*Tesla's secundar-coil*".

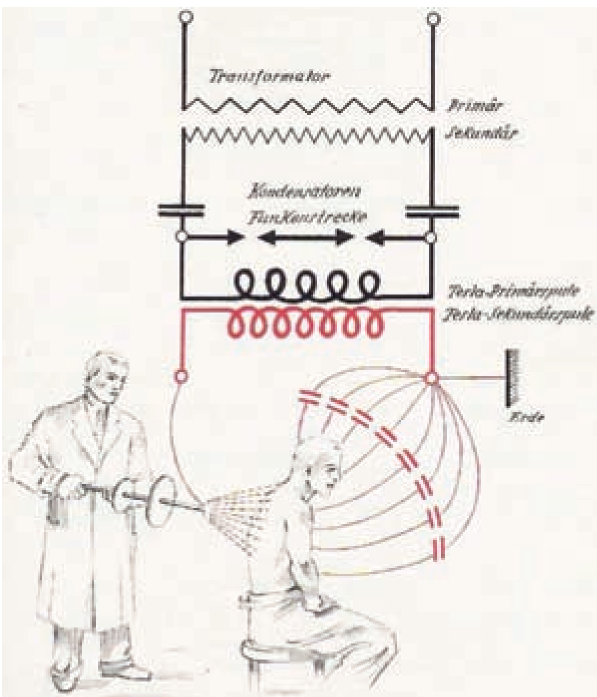


Figure 9. "*Connecting scheme and way of the current Arsonvalization"*

In the article by Professor Jozo Budak, one among the prominent persons of electrotherapy in Croatia, there was an instrument photo with an interesting signature (Fig. 10) (Budak 1945)

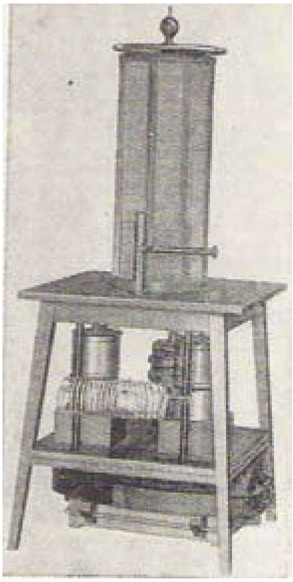


Figure 10. "*d'Arsonval's apparatus for curing by Tesla's current*"

Those and many other quotations from older literature undoubtedly show that in the first decades of Tesla's currents application in electrotherapy there was no question about a technician Nikola Tesla and a physician d'Arsonval in electrotherapy.

Teslinization or d'Arsonvalization traces

Teslinization or *d'Arsonvalization* is as a therapeutic procedure mostly given up in the middle of the 20th century. It has been kept up to this time only as a *cosmetic procedure* named *high frequency*. Up to the 1980-s the instruments were still produced with an electromagnetic switch, completely like the first Tesla's or d'Arsonval's devices of the 1890-s. Only after a complete turning to semiconductor technique the instruments are nowadays produced with an electronic switch. They are applied as a cosmetic procedure for light massage and disinfection of skin pores (on the face most of all).

Current application of alternating currents

The primary electrotherapeutic procedures by alternating currents like *Faradization, Teslinization and d'Arsovalization* were substituted by other therapeutic procedures after several decades (Jakobović 1998):

- *electostimulation,* nerve and muscle stimulation by a series of low-frequency impulses of different forms (today nearly a hundred kinds: rectangular, saw-like, composite, modulated etc.) produced by electronic devices,
- *diathermia* or *warming-through* (the term was introduced by a German physician Franz Nagelschmidt 1907/8), applied frequencies up to 1 MHz, later called *long-wave diathermia* (today it is a forbidden application),
- *short-wave diathermia* (the first *radio-cellulo oscillator,* fixed by engineer Lakhovsky in 1923, at *Salpetriere Hospital* in Paris, at the frequencies of 30,150 MHz) at present mostly at frequency 27,12 MHz,
- *microwave diathermia,* acquired as therapeutic procedure in 1947, nowadays mostly at the frequency of 2,45 GHz.

Traces of Tesla's experiments

The traces of Tesla's experiments on the effects of high-frequency currents onto living tissues and organisms have been kept in the present therapeutic procedures. In the same way as Tesla did that in his first experiments, and their demonstration also in contemporary procedures one can distinguish Tesla's ways:

a) **connecting the patient**
   - by direct connection into the current circle, or
   - putting the patient in the condenser or coil field,

b) **operating the application** of therapeutic procedure: by choosing the frequency, current power, voltage height and therapy.

Conclusion

Tesla's experiments with high-frequency currents and their effects onto living tissues and organisms were an incentive in research of their therapeutic effect.

Tesla's currents primarily produced with a sparkling oscillator were a basis for the first electro-therapeutic procedures by high-frequency currents named *Teslinization or d'Arsonvlization.*

The present electrotherapeutic procedures have developed out of those first ones: *electro-stimulation, short-wave diathermia and microwave diathermia.*

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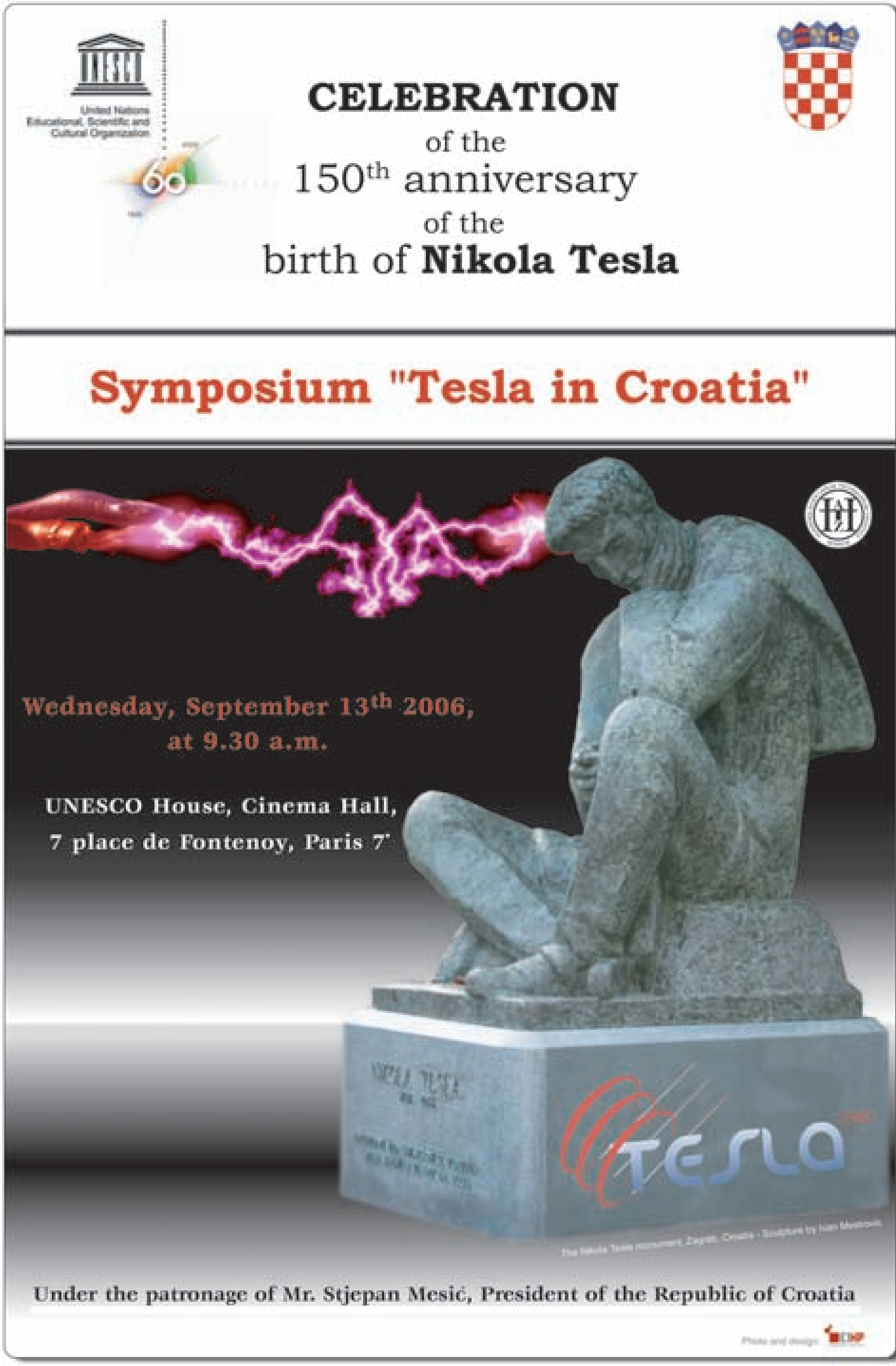
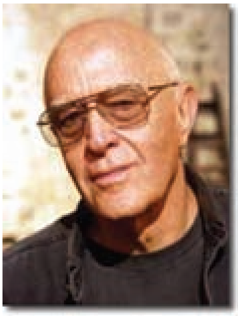
Symposium

“Tesla in Croatia”

September 13, 2006, UNESCO House,
Paris, France


United Nations
Educational, Scientific and
Cultural Organization
CELEBRATION
of the
150th anniversary
of the
birth of Nikola Tesla
Symposium "Tesla in Croatia"
Wednesday, September 13th 2006,
at 9.30 a.m.
UNESCO House, Cinema Hall,
7 place de Fontenoy, Paris 7
TESLA
Under the patronage of Mr. Stjepan Mesić, President of the Republic of Croatia
Photo and design



Prof. **Petar Selem**, Ph.D.
President of the Committee for Education, Science and Culture
of the Croatian Parliament

[1]Mesdames et Monsieurs

C'est un honeur et un plaisir de saluer cette réunion au nom du Sabor Croate et de son président, Monsieur Vladimir Šeks. Car c'est le parlement Croate qui participe activement dans les manifestations dédiées au 150ème anniversaire de la naissance de Nikola Tesla, un des personnages les plus illustres nés sur le sol croate.

Effectivement, Tesla était homme de la lumière. Et aujourd'hui, quand le monde entier se souvient de lui, nous sommes toujours fascinés par l'itinéraire d'une vie qui commence dans le petit village de Smiljane, à l'époque au bout du monde, qui se poursuivit dans les différents lieux de ses études et de son apprentissage, pour aboutir aux Etats Unis, terre promise pour les chercheurs dans les domaines tchniques. Mais il faut toutefois avouer que ce grand visionnaire, ce génie de la découverte, resterait toute sa vie durant, d'une certaine manière dans l'ombre: souvent, grâce à ses découvertes, dautres ont tiré plus de profit et plus de gloire que lui même. La gloire de Röntgen, d'Edison, de Marconi s'approprie certes d'une partie de la gloire qui revenait à Nikola Tesla. Pourquoi? Faut-il chercher les causes dans ses origines de cette terre lointaine, de son statut d'étranger, ou bien est-ce la conséquence de sa personalité éprise uniquement de la réflexion scientifique et plutôt indifférente et même étrangère aux réalités du monde réel où justement commencait la deuxième revolution industrielle? Soit l'un ou l'autre, nous revenons toujours à se statut d'étranger qui poursuivit Tesla sa vie durant.

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[1] Opening speech.

Pourtant, même si d'une certaine façon marginalisé, Tesla, par le biais de son oeuvre ce situe au centre du monde actuel, et participe aujourd'hui encore aux rythmes de son progrès. Réelment et symboliquement le Prométhée du monde actuel.

Et il était aussi le dernier et le premier. Ces, comme le disait lui même découvertes plutôt qu'inventions, êtaient en avance sur la science de son époque. Là, certainement dans beaucoup de choses il fut le premier. Mais en même temps il était le dernier homme de la science d'une allure romantique, solitaire, parfois incompris, visionnaire, renfermé sur soi même, victime parfois des dures réalités du monde dans lequel il vivait, et de la logique du profit qui était de ce monde. Il était donc solitaire. Mais aussi solidaire. Solidaire des valeurs essentielles de ce monde, du progrès, de la liberté, de la democratie. Et de son pays. Ses fameuses paroles sur son origine serbe et sa patrie croate étaient adressées à Vlatko Maček, le lider croate des années avant la seconde guerre mondiale. Et quand cette guerre éclatat Tesla s'avererait, une fois encore, solidaire des valeurs de la liberté et aussi du destin de son pays.

En effet, toujours et partout, Tesla était l'homme de la lumière.

Prof. **Tomislav Petković**, Ph.D.
Faculty of Electrical Engineering and Computing,
University of Zagreb, Croatia
e-mail: tomislav.petkovic@fer.hr

Implications of Tesla's Inventions and His Moral Character on the Development of Contemporary Science and Technology[1]

Abstract

Nikola Tesla's inventions, experiments and intuition in the fields of electrical engineering and physics, together with his ēthos, are discussed in light of the philosophy of science. Several discoveries and basic experiments in the American phase of Tesla's life, after 1884, were decisive in the development of modern technologies. Tesla's famous lecture in 1891 at Columbia University, at which he demonstrated his transformer with revolutionary applications, is recalled. The technological progress resulting from Tesla's inventions is considered in light of the history of science, with reference to H. Hertz's discovery of electromagnetic waves, four years prior to Tesla's Columbia lecture, and O. J. Lodge's famous experiments on resonant electromagnetic oscillations. Another famous European who received a glorious welcome at Columbia University in early 1939 was Enrico Fermi. His arrival in America and subsequent scientific accomplishments in both theoretical and experimental physics are somewhat reminiscent of Tesla's case. However, unlike Fermi or Heisenberg, Tesla in no way violated the integrity of his moral character through his work in electrical engineering and physics, despite extensive coercion by scientists, industrialists and politicians to change his ethical orientation. There is also a discussion of superconducting radiofrequency science and technology (SRFS&T), where the main goal today is

[1] Reprinted from *Symposium "Tesla in Croatia": Proceedings*, Croatian Academy of Engineering, ISBN 953-7076-10-5, 2006.

to achieve the highest possible cavity accelerating gradient for particles in linear superconducting colliders. The origins of this technology undoubtedly involve the use of Tesla's transformer as the source of the very high potential RF–field. Tesla's brilliant project involving a monopole antenna as the high power emitter, based on the principle of his transformer, is also discussed. Modern analysis and extensive analytical calculations within the framework of classical electromagnetic theory have been performed in order to justify the scientific foundations of Tesla's ideas on the long-distance wireless transmission of energy, information and electrical illumination. Tesla, owing to his fruitful and moral passion to help mankind through science and technology, remains an outstanding figure in the history of world science and culture.

Key words

Tesla's inventions, Tesla's transformer, Tesla's monopole antenna, accelerator technology, Tesla's intuition, Tesla's ēthos, Tesla's ethical and bioethical model for the modern sciences

1. Tesla's Legacy in Modern Science and Unique Moral Character

Nikola Tesla Year 2006 has been proclaimed by the Republic of Croatia and also by UNESCO in commemoration of the 150th anniversary of the birth of this scientific genius in Smiljan, Croatia, on July 10, 1856, owing to his scientific contributions to mankind and outstanding moral character. Croatian science, art and culture, supported by Croatian state policy at the highest level, are intent upon correlating the facts and credible sources concerning the Croatian roots of Tesla's scientific work and complex personality. Moral support for the cultural and scientific orientation of the commemoration of Nikola Tesla Year in Croatia is provided by the small fact that although the first sentence of the entry **Tesla, Nikola** in the 2004 edition of the *Encylopaedia Britannica* states that Tesla is a "Serbian-American inventor and researcher," his place of birth is given as Smiljan, Croatia. Furthermore, in a table of the parameters of lunar craters on the NASA website, next to Tesla's Crater it is stated that Tesla was a "Croatian-American inventor."

In Croatia, scientific and cultural research on Tesla's life, work and the impact of his inventions has yielded some interesting symposia, books and articles, among a sea of commemorative and historical texts in the media and *ad hoc* symposia during Nikola Tesla Year 2006. We shall mention the most important. At the state level, there was an outstanding international scientific meeting held in Zagreb, The Life and Work of Nikola Tesla, June 28–29, 2006, under the patronage of the Croatian Parliament and co-organized by the Croatian Academy of Engineering and the Ministry of Science, Education and Sports of the Republic of Croatia. The proceedings of this meeting testify to the numerous valuable contributions penned by engineers, physicists, historians, lexicographers and economists [1], including an article I contributed. On the Croatian bestseller list during the late summer was an expertly edited and attractive monograph entitled *Nikola Tesla: istraživač, izumitelj, genij* [Nikola Tesla: Researcher, Inventor and Genius] (edited by J. Lončarić, Školska knjiga, d.d., Zagreb), the work of five authors: Tanja Rudež, Vladimir Muljević, Tomislav Petković, Vladimir Paar and Darko Androić. In this volume, scientists from the University of Zagreb describe the childhood, education, patents, inventions and highlights of Tesla's activities in the United States, his inventions in physics and his engineering intuition, vision, life, achievements and overall contribution to physics. One of the authors, Tanja Rudež, provided an interesting description of Tesla's life as a visionary, incorporating heretofore unknown photographs and objects from Tesla's extended family. The cover is adorned with an original pen and ink portrait of Nikola Tesla by the great Croatian artist Miljenko Stančić. As the middle section of my scientific trilogy on Tesla, I mention my contribution to this monograph, the chapter on Tesla's inventions in physics and his engineering intuition [2]. The interesting events in Croatia during Nikola Tesla Year 2006 also include the first original Croatian scientific article, published in both Croatian and English, that deals with Tesla's long-distance electromagnetic transmission of energy and messages, published in the journal *Energija* (Hrvatska elektroprivreda, d.d., Zagreb), which by virtue of its interesting design and the quality of its articles, is the leading Croatian journal in the fields of the natural, social or related technical sciences. My article on Tesla's inventions in physics and his engineering spirit in the journal *Energija,* vol. **55** (2006), No. 3, provides a clear approach to Tesla's significant inventions, pioneering work in electromagnetic theory and their applications in modern accelerator technology [3]. In the section comparing Tesla with other great scientists who employed scientific methodology, the article, as the third part of my trilogy on Nikola Tesla, presents the "unknown" Tesla as a model for future scientists.

While working at world accelerator centers, the author of this article has had the occasion to witness the high esteem that contemporary physicists and engineers have for Tesla's research in the development of modern accelerator technology. This is one of the motives for the previously mentioned trilogy on Tesla's inventions and his engineering intuition. A second but no less important motive stems from my desire to continue a series I have written during the past decade on domestic and world scientists, philosophers and artists from the historical, scientific and philosophical points of view, including Albert Einstein, Enrico Fermi, Werner Heisenberg, Frane Petrić, Nikola Šop, Mirko Dražen Grmek and Hrvoje Požar [4] – [10], to which Nikola Tesla is a natural addition.

Nikola Tesla, owing to his inventions, broad spectrum of investigative interests and specific lifestyle, received many epithets during his lifetime, including dreamer, crazy scientist, scientific visionary, the initiator of the world wireless system and world communication, the researcher who received signals from extraterrestrial civilizations, a man who could split the earth in two like an apple, the creator of deadly penetrating long-distance rays etc. The author of this article recalls that during the 1980s, while he was performing experiments at the *SIN* Institute (later *PSI*) in Switzerland, he noticed an advertisement in the distinguished journal *Nature,* for a gathering of an international European association whose interests were exclusively oriented toward occult and parapsychological research. The association had named itself after Nikola Tesla, because that "solitary genius" best represented their aspirations and program. Although in this case Tesla's name was misappropriated, regarding the character and goals of this association, today the syntagma of Tesla as a "solitary genius" seems meaningful, not at all pejorative, as someone might think. Tesla was a loner, a brilliant inventor and a person of the highest ethical principles. Tesla was a loner, a brilliant inventor and a man of the highest ethical principles. He had the greatest respect and admiration for his parents. His father, Milutin, was the rector of a Serbian Orthodox parish. It was from his intelligent and unpretentious mother, Đuka née Mandić, that he attributed his gift for invention. Tesla had a few close friends who were writers, including Mark Twain. However, it should be emphasized that Tesla, besides his brilliant inventive abilities, intuition and photographic memory, was a perfectionist in his work (preparing and conducting experiments) and highly disciplined in his daily life (physical activities and healthful diet).

In 1917, Tesla received the Edison Medal, the highest honor awarded by the American Institute of Electrical Engineers (AIEE). On the hundredth anniversary of Tesla's birth, the unit of magnetic flux density or magnetic induction, $\vec{B}$, was named **tesla** (abbreviated as "T") in his honor. In October 1960 in Paris, at the eleventh session of the General Conference on Weights and Measures (CGPM – *Conférence Générale des Poids et Mésures*), the unit *tesla* was officially accepted and included within the International System of Units (*SI – Sistème International D'Unités*) as the SI derived unit of magnetic flux density (or magnetic induction). Its definition is as follows: 1 T = Vs/m^2 = Wb/m^2 (one tesla equals the value of the magnetic flux of one volt-second per square meter; one tesla equals the value of the magnetic flux of one weber per square meter. One tesla also corresponds to 10^4 gauss (gauss is the old unit for magnetic induction).

One of the craters on the far side of the moon (latitude 38.5N, longitude 124.7E and 43 km in diameter) was named after Tesla, which is considered to be a high scientific and cultural honor.

Tesla's most important inventions in electrical engineering are polyphase alternating currents, especially three-phase. The three-phase system is the most common and most widespread manner of producing electrical energy. In May 1885, George Westinghouse, head of the company of the same name in Pittsburgh, purchased the patent rights to Tesla's polyphase system of alternating currents, including a polyphase voltage generator, transformer and Tesla's asynchronous electrical motor on the principle of the rotating magnetic field. That year, a tremendous battle was waged between Edison's system based on direct current and the Tesla-Westinghouse alternating system. Tesla's system won, bringing humankind into the modern era of electrical energy and industry. Tesla's discovery of polyphase alternating currents remains his lasting monument and contribution to the civilization of humankind. Using three-phase currents that are sent through coils appropriately positioned in space, it is possible to obtain a magnetic field in which the magnetic field strength $\vec{H}$ always has a constant value but is rotating in space. If the coils are spaced at 120° from one another, and three-phase AC voltage (R, S, T) is applied to the coils, the resulting magnetic field strength $\vec{H}$ at the intersection point of the coil axes does not change strength but rotates following the phase sequence at an angular velocity of w. However, the metal conductor at that position starts to follow the rotating magnetic field because of the currents induced in it that are affected by the forces of the coils' magnetic field. This corresponds to the phenomenon of so-called rotating magnetism in an experiment performed in 1825 by Dominique F. Arago (October 2, 1786 – February 26, 1853), only here it is the field that turns and there the conductor turned. A rotating magnetic field is the basis of the operation of Tesla's asynchronous electric motor. Tesla received American citizenship in 1891, a year that was otherwise particularly fruitful regarding his fundamental discoveries in the field of high frequency Tesla currents (the Tesla coil, and a lecture with a demonstration of a high frequency transformer at Columbia University, New York), which will be separately discussed in this article.

Following Nikola Tesla's death on January 7, 1943, a memorial service was held in his honor on January 10, 1943, during which the mayor of New

York City, Fiorello Laguardia, delivered a eulogy, which was broadcast over New York Radio. The participants included the famous Croatian violinist Zlatko Baloković and the Slovenian choir Slovan. On January 12, approximately 2,000 persons, including Nobel prizes winners, high government officials and many other distinguished persons paid tribute to Nikola Tesla at an impressive funeral service held the Cathedral of St. John the Divine, New York City. Among the numerous telegrams, we single out those from Mrs. Eleanor Roosevelt, on behalf of herself and President Franklin Delano Roosevelt, and three Nobel Prize winners: Robert A. Millikan, Arthur H. Compton and James Franck.[2] All three, as celebrated experimental physicists, described Tesla as one of the most distinguished minds of the world, who had outlined the paths for numerous technological developments of the modern age. Tesla's letters, articles, laboratory notes, diplomas and other honors were collected by his nephew, Sava Kosanović, and later turned over to the Nikola Tesla Museum in Belgrade, where they are still preserved. Tesla maintained ties with his ethnic roots and birthplace, saying: "*I am proud of my Serbian lineage and Croatian homeland.*"

On the occasion of the 150th anniversary of Tesla's birth, in addition to his contributions to the development of science and technology, we call attention to Tesla's ethical orientation as the foundation of his life and work. It seems to us that Tesla's ethics in modern science, technology and philosophy have not been sufficiently emphasized or considered within the philosophy of science, particularly modern bioethical currents. In this article, for the first time, we shall attempt to consider Tesla's *ēthos* from a scientific and philosophical point of view in order to illuminate this dimension of his complex personality, which until now has only been mentioned incidentally. Unlike the great physicists Fermi and Heisenberg, the former involved in the Manhattan Project in the United States and the latter in the Uranium Project in Germany, it cannot be said of Tesla that his acts or insights in physics and electrical engineering violated his moral integrity, despite countless of attempts to sway his ethical orientation. In this article, it is demonstrated that Tesla's moral orientation in modern science and technology can serve as an ethical and bioethical model for the science of our time.

[2] R.A. Millikan received the Nobel Prize in 1923 for the discovery of the elementary charge of the electron and the photoelectric effect; J. Franck in 1925, together with Gustav Hertz, for research on the excitation and ionization of atoms by electron bombardment that verified the quantized nature of energy transfer; and A.H. Compton in 1927 for his explanation of the change in the wavelength of X–rays when they collide with electrons in metals, the so-called Compton effect caused by the transfer of energy from a photon to an electron.

2. Tesla's Engineering Spirit and Intuition in Electrical Engineering and Physics

Nikola Tesla's engineering spirit, like that of Michael Faraday, manifested itself throughout his life as a passion for experimentation, predominantly oriented toward innovations in physics and electrical engineering that required theoretical analysis following their discovery. Faraday and Tesla had nearly identical philosophical attitudes regarding the role of experiments in science, i.e. experiments are crucial for the development of scientific theories and important sources of new knowledge, not merely tools for the confirmation or refutation of theoretical formulations.

Among the scientific community, particularly in the fields of experimental particle physics and accelerator technology, the two hundredth anniversary of the birth of Michael Faraday (September 22, 1791 – August 25, 1867) was celebrated magnificently during the year 1991. Scientific historians took the occasion to examine his scholarly, meticulous and systematic approach to research, the like of which has rarely been encountered throughout the entire history of the natural and technical sciences. During the period between 1831 and 1862, Faraday catalogued 16,041 scientific entries on his experiments in his laboratory log. The result of all these entries can be summarized in the fundamental discovery of electromagnetism, i.e. physics as a whole, that magnetic fields are characterized by lines of force. Through original engineering experiments, although lacking extensive knowledge of the mathematics and physics of his day, M. Faraday made the development of the physics of the electromagnetic field possible, which was brilliantly formulated by James Clark Maxwell in the year 1864. We speak of Faraday-Maxwell's laying the foundations of electromagnetic theory and classical electrodynamics that served as the model for Einstein's theory of relativity and modern field theories in particle physics. Faraday's celebrated diary, consisting of seven volumes, covers the period from 1820 to 1862. His correspondence, consisting of over 4,000 letters he either wrote or received, testifies not only to the experimental style of research in the mid 19th century but also provides orientation for creative thinking in modern technologies. Tesla's notes in Colorado Springs (*Colorado Springs – Notes*) [11] and his description of his inventions (*My Inventions*) [12] are valuable sources and examples of creative thinking in modern technologies, particularly information and communication technology. Tesla's and Faraday's diaries are equally interesting from the viewpoint of the contemporary cognitive sciences.

Faraday believed that natural phenomena are linked and this was the main thread of his investigations. His work and contributions cover various areas, including chemistry and electrochemistry, electrostatics and electromagnetism (induced voltage, 1831), the experimental basis for the electromagnetic field theory and optics (the rotation of the plane of polarization of a polarized light beam by a strong magnetic field, 1845). The picture of Faraday as a scientist who worked with dedication in the basement laboratory of the Royal Institute is not a complete and accurate portrait. The experimenter Faraday was also Faraday the philosopher, an aspect of his personality that is unjustly neglected in the explanation of his life and work. In light of Faraday's original concept of the electromagnetic field, with closed lines of force in the electric and magnetic fields, he should also be remembered as the first physicist to begin the scientific dematerialization of matter. Similarly, many scholars of Faraday's life and work maintain that Faraday's Christian faith was important in his scientific endeavors. Faraday was a member of the Sandemanian sect,[3] whose beliefs are characterized by a literal understanding and interpretation of the Bible as the basis for moral values and behavior. Faraday's travels with Sir Humphrey Davy through European countries from November 1813 to April 1815 are considered to be an important element in the formation of his philosophy of research. Everything that we have said about Faraday and his philosophy of research is also more or less applicable to Nikola Tesla.

We can also justifiably compare Tesla to the German-born American physicist A. A. Michelson (Strelno, Prussia [now Strzelno, Poland], December 19, 1852 – Pasadena, California, USA, May 9, 1931), for whom the precise measurement of the speed of light through interferometric experiments were his scientific preoccupation, as the wireless transmission of energy and information (the Tesla World System) was for Nikola Tesla. In the year 1878, Michelson began work on the problem of the precise measurement of the speed of light, which was to be his scientific passion until the end of his life. In order to pursue advanced studies in optical methods, in 1880 Michelson traveled to Europe and spent two years at laboratories in Berlin, Heidelberg and Paris. In the year 1884, Tesla traveled in the opposite direction, i.e. from Europe to the United States, where he remained until the end of his life. In the year 1883, Michelson became a professor of physics at the Case Institute of Technology in Cleveland, Ohio, and completely devoted himself to the development of interferometry for the measurement of aether drift. Michelson's most significant scientific contributions were the measurement of aether drift with the null result (the Michelson-Morley experiment, first performed in Berlin, 1881, and later in Cleveland, 1887), the obtaining of the most pre-

[3] The sect was named after one of the founders: Robert Sandeman (1717–1773).

cise data of his time on the speed of light by perfecting Jean-Bernard-Léon Foucault's method of the rotating mirror (1879), and the defining and measuring of the archive meter according to the number of wavelengths of red light emitted from excited cadmium atoms (1893). Michelson was the president of the U.S. National Academy of Sciences (1923–1927), and also received the gold medal of the Royal Astronomical Society in 1923. A crater on the moon bears Michelson's name, an honor also given to Tesla. However, for the construction of the interferometer that bears Michelson's name, and for a series of spectroscopic and metrological discoveries, he was awarded the Nobel Prize in Physics in 1907, the first American in history to receive this prize. Tesla did not live to see such an honor during his lifetime and there was no such honor after his death, although there were eulogies by Nobel Prize winners on the importance of Tesla's work at his funeral in New York.

On May 20, 1891, at a conference of the American Institute of Electrical Engineers (AIEE) held at Columbia University, Nikola Tesla presented a famous lecture, Experiments with Alternate Currents of Very High Frequency and Their Application to Methods of Artificial Illumination, accompanied by brilliant experiments. The history of physics and electrical engineering recognizes Tesla's pioneering role in discerning the importance of high frequencies in the investigation of electrical and magnetic phenomena (in the electromagnetic field theory), especially in the transmission of energy and information, and in methods of electrical illumination. In the lecture, Tesla prophetically placed emphasis upon new methods for obtaining and transmitting energy, especially in the production of light, because the old heavy machinery for this would not be necessary. In the lecture, a fundamental question is touched upon regarding the nature of electricity in the context of the Theory of Aether, fifteen years before Einstein's Theory of Relativity, but with a marked phenomenological approach. Tesla proposed the name "bound aether" for the electricity that occurs in molecules, and which is important for producing light. Sir J. J. Thomson considered such a view and name to be in error. However, it should be emphasized that in 1891 Tesla correctly noted that the occurrence of light is connected with disturbances in the electrostatic charge of molecules. Tesla should undoubtedly be entitled to historical recognition as the first to demonstrate experimentally, four years after Heinrich Hertz's discovery of electromagnetic waves in 1887 as anticipated by Maxwell's equations twenty-three years earlier, that high frequencies and voltages are important for the occurrence of light and heat (electromagnetic waves) without additional chemical processes. Tesla's intuition regarding omnipresent energy and the need to harness it for the welfare of humankind is amazing.

At Columbia University, Tesla delivered another important lecture on May 16, 1888, on a new system for a motor and transformer using alternating currents. The importance of Tesla's lectures in the development of the physics and electrical engineering of the time is best confirmed by the fact that Columbia University awarded an honorary doctorate *(doctor in legibus)* to Nikola Tesla on June 13, 1894. This was the first honorary doctorate that Tesla received for his inventions, the highest recognition of the importance of his discoveries in electromagnetism. Subsequently, Tesla received more than ten honorary doctorates from universities in Europe and the United States.

In Tesla's engineering spirit, intuition was decisive. Leaving aside the scholastic tradition that distinguishes intuition from discursive cognition, considering Tesla's powerful visions and perceptions of his inventions (for example, the three-phase system and the rotating magnetic field), and their mathematical precision, we may say that Tesla had the gift of Cartesian intuitions. Tesla's intuitions of his inventions, according to the Latin *intueri,* were more than evident, and many have been very successfully applied in technology and industry. Tesla's opus includes a great number of patents, of which over 100 are in the area of electrical engineering and radio technology, constituting his greatest contribution, not only in these areas but in numerous contemporary technologies (high frequency illumination, television, the Internet and the cell phone). A digitally processed collection of Nikola Tesla's patents on CD-ROM was prepared by the State Intellectual Property Office of the Republic of Croatia (DZIV) on the occasion of Nikola Tesla Year 2006. There are 147 processed patents, according to the countries and phases of registration: 112 U.S. patents, 1885–1921, 29 British patents, 1886–1921, and 6 Canadian patents, 1886–1910.

Tesla discovered or obtained insight into his inventions in physics and electrical engineering with the same intuition that René Descartes commented upon in his first important philosophical work of a methodological nature, *Regulae ad directionem ingenii* [Rules for the Direction of our Native Intelligence]. Descartes probably wrote this brief work around the year 1628 or some years earlier. In the commentary on the third rule that speaks of intuition, Descartes created an interesting concept of the light of reason (Latin: *ratione luce*, in the French language: *lumière innée, lumière naturelle)*. Nikola Tesla approaches Descartes' ideal with his fundamental discoveries in electromagnetism and the corresponding technologies.

3. Applications of Tesla's Transformer in the Long-Distance Wireless Transmission of Energy and/or Messages and Modern Radio Frequency Technologies

Tesla's high frequency transformer (RF transformer) was truly a breakthrough in the development of modern radio frequency technology. We recall the experiments by Sir Oliver J. Lodge (June 12, 1851 – August 22, 1940) using electromagnetic oscillating circuits. Lodge was an English physicist, radio pioneer and the inventor of the coherer electromagnetic wave detector. Lodge's experiments are based upon two oscillating circuits that are spaced apart, consisting of capacitors (Leyden jars) and rectangular loops. A high-voltage DC generator charges up the capacitor in the first oscillating circuit. At some point, the capacitor discharges via a spark gap into the rectangular loop that has the role of an inductor. In Lodge's second oscillating circuit, separated by a space from the first one, the inside and the outside surfaces of the Leyden jar were connected to the rectangular loop and a movable loop that could slide across the rectangular loop. In this manner, the inductance changes and the frequency of the oscillating circuit are tuned. The second oscillating circuit has an auxiliary spark gap to detect oscillation in the second circuit. When the second oscillating circuit is close to the first one, and if the movable loop is in the resonance position, sparks in the auxiliary spark gap are generated, indicating that the charge in the second loop is oscillating at the same frequency as in the first loop. We can say that Lodge's oscillating circuits are in resonance because the electromagnetic lines of force in the first and second loop are coupled, which generates the oscillation of the charge in the second circuit. Within the context of Lodge's pioneering experiments, Tesla's achievements can be appreciated. He moved the second oscillating circuit into the center of the primary coil, thus inventing the Tesla transformer. This was Tesla's revolution in the field of high frequency technology.

3.1. Tesla's Transformer in the Development of Accelerator Technology

Tesla's high frequency transformer, without the characteristic iron core, is a resonant transformer with a high voltage secondary coil. A primary coil with several turns is part of the primary oscillating circuit together with the Tesla spark gap. The long secondary coil with many turns and stray capacitance between its turns is equivalent to a high frequency resonant circuit. The highest voltage and best tuning are achieved when the secondary coil is a part of the resonant circuit and when it is tuned to the resonant frequency of the secondary coil. This can be expressed as follows: $L_1C_1 = L_2C_2$, obtained by applying the Thomson equation for the resonant tuning (linkage) of the oscillating circuits. Tesla's transformer is a source of high-frequency high-power electromagnetic fields. An equivalent scheme of the transformer, with the distributed stray capacitance of the secondary coil (C_2) indicated, is presented in Figure 1.

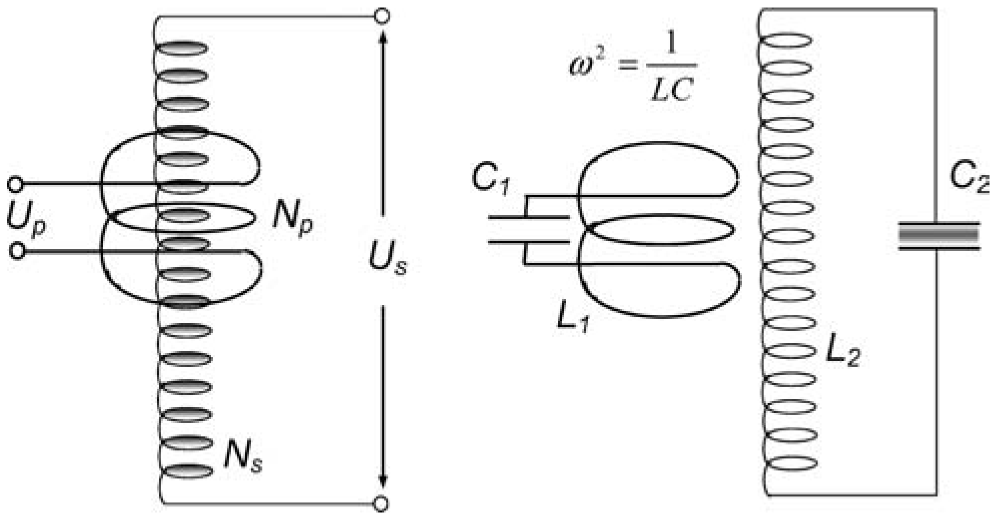

Figure 1. Equivalent scheme of Tesla's RF transformer. The voltage at the end of the long secondary coil is as follows: $U_s = U_P \cdot N_s / N_P$ under the following condition: $N_S >> N_P$ (the numbers of the turns of the secondary and primary coils).

In Tesla's original calculations, according to his records in Colorado Springs [11], he determined the length of the wire of the secondary coil of the transformer so that it corresponded to a quarter of the wavelength of the electromagnetic waves in free space.

Tesla's fundamental invention for the investigation of electromagnetic phenomena was the Tesla coil. It is a cylindrical coil (one or several turns), made of copper or some other conductor. It is actually an oscillating transformer with primary and secondary condensers and a current switch (spark gap). When high frequency current passes through the coil, the magnetic field in the coil changes very rapidly. These changes in the magnetic flux are perpendicularly enclosed by the li l nes of force of the electrical field. If the coil is located in a rarified gas (for example, air) and if the intensity of the electrical field is sufficiently high, discharge into the gas occurs and a pink ring is seen around the Tesla coil that mimics the form of the coil or the closed electrical lines of force. Tesla discovered the coil in the year 1891 and it is used today in radio, television and many electronic devices.

In the presentation of the development of accelerator particle physics, especially the technology of linear particle accelerators, no one has so concisely and responsibly presented the role of Tesla's high frequency transformer as Prof. Helmut Wiedemann, Ph.D., from the Department of Applied Physics, Stanford University, at the Stanford Synchrotron Radiation Laboratory [13]. In such development, sources of RF fields of suitable power also have an important role today. Tesla's RF transformer without an iron core was a breakthrough, especially due to the high voltages that can be obtained from the end of its secondary coil. During a half-period of voltage oscillation on the secondary coil, the voltage is used for accelerating the pulses of the particles (beam) in the accelerator channel. This method is particularly used in high technology today, especially in superconductor electron beam accelerators.

We shall describe it briefly, using the example of the Thomas Jefferson National Accelerator Facility (TJNAF, Newport News, Virginia, USA), one of the most famous superconductor electron accelerators in the world, where basic research in particle physics and nuclear physics is being conducted based upon quark models, superconductivity, the physics of materials and surfaces, the physics of lasers, applied research in medicine and biotechnologies, and various industrial applications. In the main channels in the form of an elongated ellipse, approximately 1 mile in length (roughly 1.6 km), there are two linear electron accelerators (so-called north and south *linac*) that together have 320 RF cavities in superconducting technology (material niobium *Nb*, critical or transition temperature to the superconducting state T_k = 9.3 K). In each accelerator, the energy of the electron beam is increased by 400 MeV. A billion (10^9) times per second, it focuses a million (10^6) electrons in order to obtain a continuous electron beam of the thickness of a human hair, with a diameter of approximately 200 μm (see the lower figure of Fig. 2). The acceleration of the electrons in the resonators is achieved using an RF field. The electron beam is accelerated linearly and synchronously arrives at the descending positive half-wave of the RF signal along the axial axis of the resonator each time. In branches of science and technology, very interesting technological developments and discoveries are occurring in our times involving the applications of radio frequencies in linear accelerators. There have been developments concerning the central problem, achieving the maximum possible gradient of particle acceleration in linear accelerators, expressed in units of MV/m (megavolts/meter). The goal is to deliver the maximum energy to a particle (beam) per unit length of the cavity in which the acceleration occurs. In the superconducting linear colliders operating today at –271° C (2.15 K), the accelerating gradient typically amounts to 28 MV/m. The most recent technological development at the Jefferson Laboratory in the year 2006 makes a gradient of 35 MV/m possible, while the world record known as the Cornell result of 46 MV/m was achieved in late 2004 (published in the year 2005). In the Cornell University Laboratory for Elementary-Particle Physics (LEPP, Ithaca, NY 14853, USA), the highest accelerating gradient of 46 MV/m in a superconducting niobium RF resonator at a temperature of 1.9 K has been achieved [14].

The roots of the cited achievements in the development of modern accelerator technology are in Tesla's transformer and the high frequency voltages obtained with it. The 1st TESLA Workshop, i.e. the first international workshop on radio frequency technology in superconducting linear accelerators, was held at Cornell University in the year 1990 [14].

At the Cornell University Laboratory for Elementary-Particle Physics (LEPP), there have been significant advances toward the fundamental goal of the maximum accelerating gradient in superconducting technology. The TESLA Technology Collaboration is located at Cornell. Its ambitious research and development programs are oriented toward three goals: (i) maximum accelerating gradient, (ii) simultaneous enhancement and preservation of the value of the Q-factor or the quality of the resonator and (iii) the geometric optimization of the shape and materials of the resonator or cavity. The achievement of these goals corresponds to the energy of the particle beam (typical electron beam) in the high terra-electron-volt region in superconducting linear accelerators. The previously mentioned peak maximum accelerating gradient of 40 MV/m stems from fundamental limitations due to the breakdown of superconductivity at the surface of the resonator. In this lies the greatest challenge: finding the shape for the beam aperture of the resonator and the entire ideal shape for the resonator in order to achieve the stated goals. The technological version of the resonator is called the Tesla resonator, after the project of the same name at Cornell. The most recent results refer to the technological improvement of the customary Tesla resonator as a more advanced resonator with a new "re-entrant" cavity shape. The two are compared in Fig. 2, according to photographs from Cornell and CERN dated 2006. The new resonator is characterized by a reduction in the ratio of the peak magnetic field value to that of the accelerating gradient (over 10% in comparison to the standard Tesla resonator). The downside of the new shape of the new resonator permits higher electric fields on its surface, which results in a higher electric field for the acceleration of the electron beam.

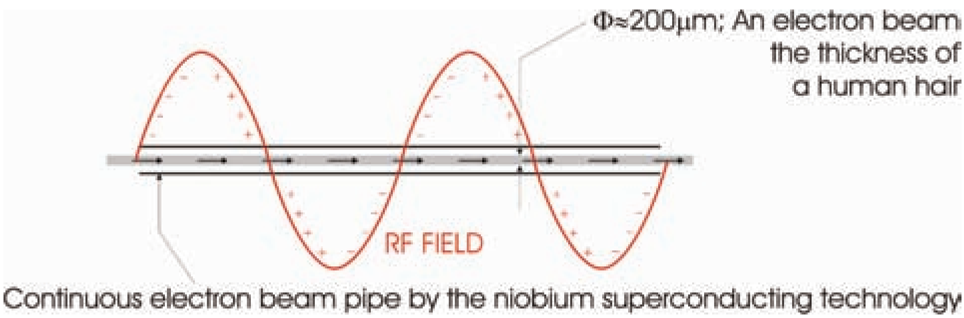

Figure 2. A photograph from Cornell and CERN in 2006 (above): a comparison of the standard Tesla resonator or cavity (left) and the new resonator (right) of a "re-entrant" cavity shape. The lower figure is a phenomenological representation of the acceleration of an electron beam in an accelerator pipe, and the electric voltage of acceleration obtained using the Tesla transformer method (author's concept). The physical picture is based on the situation that the force $\vec{F}$ acts on the continuous electron beam in the pipe as a negative accelerating gradient of voltage U ($\vec{F} = -\vec{\nabla}U$).

3.2. Analysis of Tesla's Monopole Antenna for Electromagnetic Waves of High Power and Range within the Framework of Classical Electromagnetic Theory

In our times, Tesla is one of the most frequently mentioned scientists on the Internet. Various websites describe and comment on his life and work, especially his patents and inventions. There are frequent web articles on Tesla's idea for the technical implementation of a world wireless system (the long-distance transmission of energy or messages). These scientific and frequently pseudoscientific articles contain analyses of actual Tesla towers with RF oscillators and transformers for the emission and wireless transmission of electromagnetic energy, based upon Tesla's research notes (*Colorado Springs – Notes*, June 1, 1899 to January 7, 1900, see [11]). One of Tesla's chief experimental discoveries from the measurements at Colorado Springs was that stationary waves are propagated through the earth. He continued this investigation with the construction of a massive tower for *world telegraphy* on Long Island in 1900–1902, which remained Tesla's unfinished project! Tesla's laboratory and tower on Long Island were devoted to fundamental experiments for the purpose of attempting to confirm his new model for the propagation of RF waves and the transmission of energy, unlike the standard Hertz model of directed radiation through free space. Tesla's scientific-technological areas of interest were fundamentally diverse: (i) authentic proofs of the earth's stationary waves (already noted in the research in Colorado Springs) that could serve for the economical transmission of energy on a large industrial scale and in the system of the earth-ionosphere for transcontinental (global) communication; (ii) the evidence of the model of the earth as a conductor and resonant system with low characteristic frequencies (6, 18, 30 Hz, Tesla's numbers); and (iii) the experimental search for the optimal transmitter ($\lambda/4$ monopole antenna) in the antenna-ground system, in view of the optimal technical ratio in electromagnetic transmission between the propagation of energy by EM waves and the energy current that travels the earth. The research and experiments on Long Island using the wireless transmission tower were supposed to be Tesla's crowning contributions to electromagnetic theory and technology, with revolutionary applications in wireless communication and energetics. This was the famous Tesla Wardenclyffe Project in the locality of Wardenclyffe, now Shoreham, Long Island, New York. The huge 187-foot (57-m) tower, designed according to Tesla's specifications by the famous American architect Stanford White, was erected in the year 1901. The project was terminated, however, in 1905 when its main backer, J. P. Morgan, refused to finance it further.[4]

Tesla's model of the long-distance wireless transmission of electromagnetic power or messages based on his fundamental intuition about the

[4] It is interesting that the Tesla Wardenclyffe Project was revived as an aspect of Tesla's legacy in 2006 in Shoreham by the Tesla Science Center at Wardenclyffe. This center is also preparing an international conference in commemoration of the 150th anniversary of Tesla's birth, the First Tesla Museum and Science Center International Conference on Nikola Tesla, October 6–8, 2006, in Brookhaven, Farmingville, N. Y.

world wireless system is attracting renewed attention in 2006, on the occasion of the 150th anniversary of Tesla's birth and Nikola Tesla Year. Tesla believed that his transmission model using the antenna-ground system could transmit nearly 90% of the energy via the earth's surface and the remaining 10% via electromagnetic Hertz waves through the atmosphere. He attempted to construct a powerful transmitter for such transmission and determine wavelengths reliably through experiments, with the goal of defining the phenomenological laws of propagation through the earth and air. He attempted to construct a powerful transmitter for such transmission and determine wavelengths reliably through experiments, with the goal of defining the phenomenological laws of propagation through the earth and air. Tesla's antenna (transmitter, tower) was supposed to have weak impedance matching for the free space, in order to decrease wave energy propagation. In Hertz's transmission mode, the goal was the optimal matching of the antenna to the free space (377 Ω).

Arnold Sommerfeld, one of the most famous German physicists, was also engaged in the theoretical propagation of waves in wireless telegraphy during 1909 [15]. In addition to Sommerfeld, Jonathan Zenneck was also engaged in the wireless propagation of waves via air-ground, as two media. From the development of electromagnetic theory, it is known that wireless communication can be based upon the Zenneck-Sommerfeld solution to Maxwell's equations that particularly describe the propagation of waves by the earth's surface. In addition to Zenneck's and/or Sommerfeld's surface waves [15], there were many useful solutions later along this line of research. Tesla felt that such solutions provided great support for his model.

Electromagnetic calculations have once again been performed and revised for Tesla's approach, based on energy transmission by the earth and Hertz's approach using free space, and the results were published in the first original scientific article during Nikola Tesla Year 2006 in Croatia. This concerns the previously mentioned article in the journal *Energija* [3]. Tesla's device for the antenna-earth system is presented in Fig. 3. The oscillator operates at a frequency of 100 kHz. Tesla's transformer has a weak coupling and is used for adjusting the device. The monopole antenna has capacitive reactance that must be cancelled by inductive reactance, which is achieved via an additional serial coil (transformer), in which case there is maximum transmission of power to the antenna. The antenna is 60 m in length, rod-like and monopolar. The practical criteria of monopolarity according to the distribution of current on the antenna determine the length of a monopole antenna, which is less than of $\lambda/8$. In this case, the criteria are met: L < $\lambda/8$, (60 < 375). Since the device is authentically Tesla's, in this article we are presenting it with the corresponding physical parameters, descriptions and commentaries regarding our solutions. A monopole antenna is a single pole (half) half-wave antenna, the technical usefulness of which is based upon the phenomenon that the soil is a good conductor of low frequency currents of the two media (from 10 kHz to approximately 30 MHz). A monopole will be analyzed with a linear polarization (polarization of the electrical wave field radiated from the monopole), while the antenna is erected vertically to the ground. At vertical polarization, the imaged current has a value and direction that support the radiation emitted by the real monopole (Fig. 3). This is not the case for horizontal polarization: the current and its associated image are mutually compensatory. Therefore, vertical polarization is used because in the upper half of the space, the field of the monopole has the same intensity as in the case of a dipole. The purpose of such analysis is to provide detailed calculation and a mathematical demonstration, particularly at great distances from the radiating monopole (source). Such calculations assume that certain prerequisites have been met. The first is that the soil is ideally conductive or at least somewhat ideally conductive, so that the entire induced charge in the soil from the antenna charge appears as a surface charge at the phases between the soil and free space. It is assumed that such a charge is equal to that of the antenna (these conditions are met for ideal conductivity and for the dielectric constant of the soil that is far greater than that of the free space), and if it is known from the electrostatic image theory that the imaged charge does not depend on the coordinates, but rather upon the previously mentioned ratio of the dielectric constants, it is possible to present the distribution of the imaged charge using the same function as for the distribution of the current on the monopole.

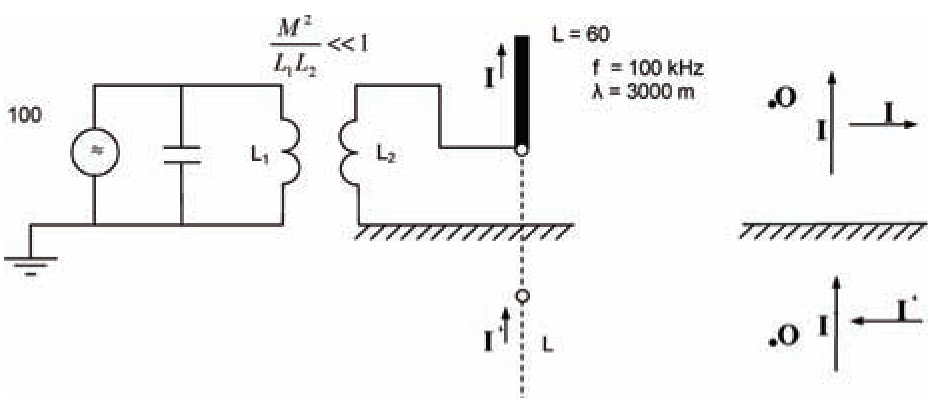

Figure 3. Tesla's device for the antenna-ground system. The modern scientific scheme of the equipment intended for the experimental investigation of Tesla's model of the wireless transmission of electromagnetic power or information based upon the fundamental concept of the wireless system.

The article concerns an analysis of Tesla's monopole antenna, based upon his fundamental research in Colorado Springs and Long Island in which such an antenna had a crucial role in the equipment for the long-distance transmission of electrical energy (Tesla's U.S. Patent No. 1 119 732 for an "Apparatus for Transmitting Electrical Energy," was filed on January 18, 1902 and registered on December 1, 1914). In this article, we performed original calculations of the wave intensity (RF field) and Poynting's power flow at significant distances from the antenna. The scientific motive is to confirm or refute Tesla's fundamental ideas in electromagnetic theory and applications at RF frequencies. The analytical calculations show that the electromagnetic field is small and the power is quite weak at great distances from the monopole. The entire calculation was performed for an ideal monopole: a monopole with a length far longer than that of the radius of the cross section, so that the influence of resistance loss is negligible in this case. Moreover, soil is never ideally conductive and, therefore, the consequent losses are very great. There are also great losses in the antenna coil. Some improvement is achieved by burying a metal strip in the soil under the monopole or by modifying the monopole itself. The monopole is bent at the tip in the form of the letter L or T, or has a sphere at the tip. The sphere receives a certain amount of charge and thereby increases the current distribution surface. The L or T tip of the monopole performs the same role. Thereby, emission for such real modified monopoles is intensified. Transmission via the earth's surface (Tesla's mode) seems naturally and technically justified, as demonstrated by these calculations. Unfortunately, such transmission has remained a mere dream because Tesla did not complete his research or provide a technical solution, although his ideas were well founded scientifically.

4. Tesla's *Ēthos* (Moral Character) in Light of Contemporary Ethics and Bioethics

Tesla's moral character during both the European and American phases of his scientific research is perfectly congruent with Aristotle's concept of *ēthos*, which is customarily translated as *moral character* in Aristotle's ethics. According to the Aristotelian interpretation of moral philosophy, Tesla's rational decisions regarding his patents and inventions in physics and electrical engineering have devolved to serve the good of the person and humankind as a whole. None of Tesla's acts in science and technology violated the integrity of his moral character in any way, despite extensive coercion by scientists, industrialists and politicians to alter his fundamental ethical orientation. He is an exemplary figure in modern science, technology and philosophy. There have been no applications of Tesla's numerous industrial, scientific and technological patents for unethical or destructive ends. Tesla should be viewed as an ethical and bioethical model in modern science and technology by virtue of his unclouded life and work. The moral character of Tesla's work becomes particularly apparent when contrasted with that of scientists such as A. Einstein, E. Fermi and W. Heisenberg, whose discoveries either devolved to catastrophic applications, such as the atomic bomb, or who directly participated in the development of nuclear weaponry during the Second World War. These great physicists are universally venerated in popular as well as serious philosophical and scientific circles. Nonetheless, Nikola Tesla represents sharply contrasting values.

We shall briefly consider Fermi and Heisenberg, about whom the author of this article has recently published works. Fermi and Tesla have already been formally mentioned together in this article as Europeans whose American successes both began with their arrival at Columbia University in New York. I have written previously about Enrico Fermi regarding the question of the moral responsibility of scientists in terms of bioethics, as the last universal physicist of the 20th century [4]. Enrico Fermi, the celebrated Italian physicist who had discovered neutron-induced radioactivity, the recipient of the 1938 Nobel Prize in Physics, arrived in New York on January 2, 1939. Less than two weeks after his arrival, Niels Bohr, the recipient of the 1922 Nobel Prize in Physics, arrived in New York and brought news of the discovery of the concept of nuclear fission by Otto Hahn, Fritz Strassmann and Lise Meitner. Fermi was welcomed in America as the ideal physicist who would continue his European research on nuclear reactions with neutrons. At Columbia University, he soon formed a group of physicists around himself (Herbert L. Anderson, Leo Szilard and Walter H. Zin), with the goal of investigating the fission of uranium nuclei. The group soon confirmed experimentally that ^{235}U is the fission isotope of uranium and that its fission is triggered by thermal neutrons. Thus, E. Fermi successfully began the American phase of his research at Columbia University in New York, as Nikola Tesla had done before him. Is Fermi's participation in the Manhattan Project for the development of the atomic bomb a stain upon his reputation as the last universal scientist? In my research into Fermi's life and work, I have concluded that Fermi's Italian phase up to the year 1938 was impeccable in the bioethical sense. In the American phase, the universality of Fermi's Italian phase was compromised by his role in the discovery, testing and use of atomic bombs in Japan during 1945. Fermi, like other great physicists confronting the moral dilemmas concerning the use of the atomic bomb, did not virtually calculate all the bioethical consequences and dangers to humankind. However, he was better acquainted with them than the others who participated in the project. Contemporary bioethical paradigms, unlike paradigms in physics, chemistry or even traditional ethics, do not provide stipulated postulates and laws in advance, i.e. final truths of a metaphysical or theological nature. Bioethics is more interdisciplinary, posing and preparing new universal paradigms rather than ultimately answering Pilate's famous question to Jesus: "What is truth?" (to which Jesus replies that everyone who belongs to the truth listens to his voice). Bioethics is primarily founded upon knowledge as such and the universal morality of the survival of life in the universe. Tesla's European and American phases were identical and unbroken in the ethical and bioethical senses, perfectly unclouded, in which it is not possible to discover any partial or general interest or intention except scientific and technological research for the good of humankind. This does not diminish Tesla's field of activity and research in electromagnetic theory and electrical engineering applications, as might be said of the great theory of nuclear physics of the 20th century and the applications of nuclear energy. It is generally acknowledged that Einstein's space-time relativity in physics with its new vision of the universe, quantum mechanics with its new vision of nature and natural phenomena, revolutionary philosophical ideas and man's role in the natural laws, together with the discoveries in nuclear physics of the 20th century, promised new meaning and function for theoretical and experimental research in the modern age. However, the brilliant electromagnetic theory that developed in the 19th century, culminating in Nikola Tesla's magnificent inventions, stands side by side with these other great theories. Its development in the physics of lasers, and information and communication in the foundation of the global electromagnetic culture of our times, and Tesla's crucial contributions, without which such development would not have occurred, only confirm and justify our original notion of Tesla's *ēthos* in modern electrical engineering and physics.

When describing Tesla's scientific orientation, we recall the great physicist Heisenberg, his *ēthos* and scientific activity during the Nazi era in Germany, which continue to remain intriguing when considered within the legal and moral context of that time. Heisenberg, in response to the delicacy of his own situation as a leading physicist and philosopher, developed his principle of responsibility (*Verantwortung des Wissenschaftlers*) as a contribution to the ethical conflict between moral obligation and obedience to authority. I refer to my scientific and philosophical study of Heisenberg's case over the years, regarding contemporary moral dilemmas in science and technology in light of modern bioethical considerations. An article has recently been published on Heisenberg's life and works during the Nazi phase [6], and we particularly recall the moral model of Tesla's life and work. Although Tesla's trials are not comparable to those endured by Heisenberg under the conditions of the Third Reich, the obstacles Tesla encountered during his lifetime were not trivial.

Despite obstacles, disappointments and the failure to implement some of his great scientific intuitions during his life, there is a prevailing conviction that we still do not know Tesla, particularly in light of his famous statement: "The future belongs to me." Together with contemporary accelerator technology and all the inventions and intuitions we have described, exotic experiments in teleportation, Kirlian photography (invisible phenomena) and the missing objects and written notes which the secret services confiscated at the time of Tesla's death and burial are also aspects of Tesla's genius. In any case, Tesla's moral character remains resplendent.

5. Tesla's Inventions in the Foundations of Contemporary World Science and Electromagnetic Culture

It is known that Tesla studied the longest and best at the *Technische Hochschule* in Graz (1875–1878), and continued his education in Prague. He enrolled in the study of natural philosophy in 1880 at the University of Prague but already in 1881 went to Budapest, where he was employed at the Central Telegraphic Office. While in Budapest in February 1882, he experienced the most significant intuition of his life regarding the rotating magnetic field, which can practically be considered as the hallmark of electromagnetic technology. Walking in the city park with his friend Antal Szigety, reciting an excerpt from Goethe's *Faust,* "Before the City Gates," [5]. the idea of the rotating magnetic field struck Tesla like a bolt of lightning. He immediately drew a diagram of such a field in the sand with a stick, which Szigety understood at once. Thus, the ancient Greek Platonic situation was repeated when Socrates successfully explained the Pythagorean Theorem to a slave by making a drawing in the sand (*Meno,* dialogue from the transitional period of Plato's works). In *Faust,* Goethe tells of the struggle between good and evil, the spirit and body, life and nihilism, on the highest cosmic scale. The moving force and main protagonist in this struggle on the one side is the scientist Faust, disappointed and restless in his scientific aspirations, and on the other side is the sa-

[5] Johann Wolfgang Goethe, Faust I und Faust II, Eine Tragödie, Werke Sechster Band, Insel Verlag, Frankfurt am Main, 1981, Faust I, Vor dem Tor, S. 45

tanic figure of Mephistopheles, a partner and opponent on Faust's investigative journey. Such a philosophical and poetic-mystical image made a profound impression on Tesla and greatly attracted him throughout his life. It was particularly Faust's philosophical choice, the rejection of the joys of this world as offered by Mephistopheles in favor of a fundamental commitment to human creativity, work and freedom, which signifies the historical and cosmic advancement of humankind.

There has been considerable recognition afforded to Tesla's inventions in physics and electrical engineering in Croatia. This is not merely due to an affinity toward a researcher from our homeland but the creative interest by Croatian university instructors of physics and electrical engineering in incorporating Tesla's ideas into the curricula. Such an attitude toward Tesla has also been expressed through the high honors that have been awarded by the Croatian scientific and cultural milieu. Nikola Tesla was chosen as an honorary member of the Yugoslav Academy of Arts and Sciences (today the Croatian Academy of Arts and Sciences) in 1896. On June 29, 1926, he received an honorary doctorate (*doctor honoris causa*) from the Department of Electrical Engineering, Faculty of Technology; University of the Kingdom of the Serbs, Croats and Slovenes, in Zagreb, which was presented to him in New York on the occasion of his 70th birthday, the first honorary doctorate of natural sciences awarded by the university. We present a translation of the listings of the original rulings and documents in the catalogue section of the archives of the University of Zagreb.

DOCTOR HONORIS CAUSA, *NIKOLA TESLA*, Zagreb 1926

Nikola Tesla, scientist in the field of electrical engineering of worldwide reputation, received an honorary doctorate on June 29, 1926, in commemoration of the 70th anniversary of his birth. He is the first in the natural sciences to receive an honorary doctorate from the University of Zagreb

The text of the ruling of the Faculty of Technology, the University of the Serbs, Croats and Slovenes in Zagreb, dated May 28, 1926, on the awarding of an honorary doctorate of technical sciences to Nikola Tesla.

The text of a letter from the rector, Drago Perović, sent to the Office of the Dean of the Faculty of Technology on June 2, 1926, regarding the ruling of the University Council on the awarding of an honorary doctorate to Nikola Tesla.

Archives of the University of Zagreb, Rectorate, No. 2115/1926

Legend: *Doctor honoris causa*, spis, 1926, format A4, 2 pages, Nikola Tesla, the first honorary doctor of natural sciences awarded by the University of Zagreb

The rector's chain of office of the University of Zagreb dates from the year 1880 and is fashioned of a series of medallions with the likenesses of distinguished Croatian scientists and artists. On the occasion 300th anniversary of the University of Zagreb, 1969, a new rector's chain was fashioned with medallions of distinguished figures from the history of Croatian science, including one with the likeness of Nikola Tesla (the work of the academic sculptor K. Angeli Radovani). In the center of the city of Zagreb, a statute of Nikola Tesla (Fig. 4) has been erected, the work of the greatest Croatian sculptor, Ivan Meštrović. The statue was originally placed in the park of the Ruđer Bošković Institute in 1956 but during the series of events in commemoration of Nikola Tesla Year 2006 in Croatia, it was moved to the center of the city, at the intersection of Tesla Street, Preradović Street and Masaryk Street.

It should be noted that Tesla's experiments and attempts in physics and electrical engineering were not exclusively intended for patents. Nikola

Figure 4. The city of Zagreb erected a monument to Nikola Tesla near the entrance to Nikola Tesla Street. The inscription on the base reads as follows: "Nikola Tesla, 1856–1943, in commemoration of the 150th anniversary of his birth, the City of Zagreb, July 10, 2006."

Tesla was a pioneer of public scientific experiments in electromagnetism, particularly during the American phase of his life and research. Tesla's experiments were magnificent. In addition to those concerning inventions, there were also those that were instructive, of the type known as the so-called *expĕrīmentum explānātum* – explanatory experiment, an experiment that *interprets* and *demonstrates,* but also *substantiates* a phenomenon. In the physics of the 21st century, great accelerator experiments in the world are being conducted, which include enormous accelerator facilities to be used for accelerating high energy beam particles, the colliding of which provide new scientific insights and data of significance to *particle physics* and *cosmology* (standard model), or as popularly expressed in contemporary physics, for *the theory of everything that exists.* At one time, great experiments were performed by one, two or three physicists. Contemporary great experiments are on a grandiose international scale in terms of the numbers of participants and countries that support them, but also because they unite the three most significant scientific approaches of our modern civilization: *theory, experiment* and *simulation*, as never before (see [17]). Moreover, with and for them, a *fourth* approach is being developed toward public opinion – the path of the popularization of new scientific knowledge, testimonies and information that such experiments yield, as well as the explanation of complex ideas regarding the conducting experiments. This is an essential characteristic of all accelerator experiments, from CERN, Fermilab (United States), DESY (Germany), to KEK (Japan). Every great experiment is necessarily accompanied by a popular scientific film, flyer or some other explanation to the various available mass media.

Heinrich Rudolf Hertz, Tesla's contemporary who discovered electromagnetic waves in 1887, announced on that occasion his inexhaustible belief in the power of the scientific experiment. Hertz's words still apply today: "What is due to experiment may always be rectified by experiment." Tesla's *credo* was similar: to demonstrate the power of electromagnetic theory with experiments, particularly in the long-distance wireless transmission of energy, messages and illumination.

Information and communication technology (in philosophical language the "electromagnetic culture") is in the background of the contemporary processes of globalization and global networking, e.g. the Internet. The high density, high volume flow of information at the greatest possible speeds corresponds to Descartes metaphysical ideal concept of the *light of reason* [18]. Tesla's inventions, patents and experiments are incorporated in the foundations of contemporary culture. Tesla's name, work and his cosmopolitism, particularly his moral character and passion to help humankind through science, are paragons of human science and culture.

Acknowledgments

I acknowledge valuable discussions on the topics of technology, physics and philosophy in the paper with my sons T. Petković jr. and K. Petković, both scientific novices/assistants at the Faculty of Electrical Engineering and Computing and Faculty of Political Science of the University of Zagreb, respectively. I thank Professor Z. Kniewald, president of the Croatian Academy of Engineering, who included my paper in the prestigious symposium, "Tesla in Croatia," to be held in Paris on September 13, 2006. Ms. M. Casman-Vuko and Mr. M. Vuko translated the Croatian original of the paper into English with interest and great effort.

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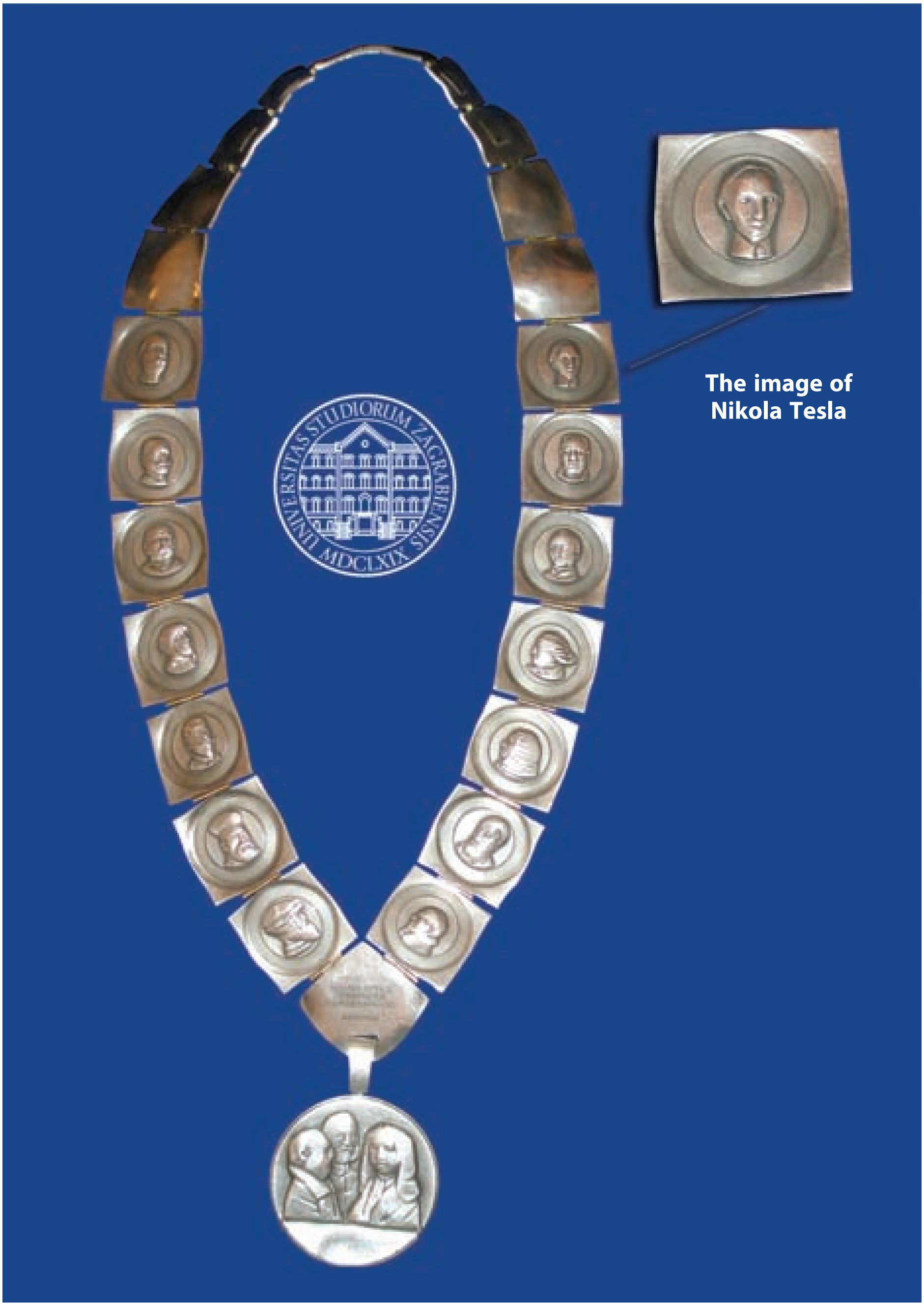

The Rector's chain of the University of Zagreb made of silver in 1969
for the 300th anniversary of the University, used continuously ever since

Author of the Rector's chain: Kosta Angeli Radovani

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Nikola Tesla' European Time[1]

In 2006 we celebrate the several outstanding personalities, like Wolfgang Amadeus Mozart, Sigmund Freud, Berthold Brecht, and, last not least Nikola Tesla. On the 10th July 1856 Nikola Tesla was born, the "Man who Invented the 20th Century" as the Austrian newspaper "Der Standard" entitled an article in 1992. On the 17th January 1756 Mozart was born and 100 years later, Tesla, two geniuses who were so different and yet very similar in their ingenuity. I even dare to compare Tesla and Mozart two outstanding personalities whose achievements, of course, were totally different. Mozart, for instance, wrote more than 600 compositions while Tesla's patented inventions count more than 200, some even count 700. Both had the ability to develop and design their ideas in their heads so completely that no corrections were necessary to be made at the later stage of realisation. Mozart's handwritten handwritten sheets of music of his compositions show almost no corrections. It was the same with Tesla who said about himself, that he had developed all his inventions and experiments in his head ready for realization. Tesla once wrote "The images I saw were to me perfectly real and tangible".

Tesla was a marvellous inventor, an "Ingenieur" in the very meaning of the word ingenious and not an engineer the roots of which are the engine. In my presentation I will try to cover the time Tesla lived, studied

[1] Reprinted from *Symposium "Tesla in Croatia": Proceedings*, Croatian Academy of Engineering, ISBN 953-7076-10-5, 2006.

Figure 1. The k.k. Austro-Hungarian Monarchy (1914 and after World War I)

and worked in Europe before he left for the United States of America in 1884 to work as an employee of Thomas Alva Edison.

In my presentation I will try to cover the part of Tesla's time before he left Europe emigrating to the United States of America.

As one of 5 children Nikola Tesla was born in Smiljan in the province of Lika, which was in the frontier lands between the KK Austro-Hungarian Monarchy, one of the strong powers in Europe and the Osman Empire. Figure 1 shows the map Austria– Hungary before and after World War I, when it fell apart into several states of various nationalities.

Tesla was born after the Crimean War and died during the most disastrous World War II. No wonder he became a pacifist as so many others.

As a young boy he very soon became passionate about reading first in the library of his father who was a Serbian-Orthodox clergyman. However, after he had met Edison in USA Tesla believed he "… had studied a dozen languages, delved in literature and art, and had spent all my best years in libraries reading all sorts of stuff that fell in my hands". Later he became extremely self-disciplined and accurate. He learned to memorize whole books with poems which seems that he had trained his brain so much that he could imagine complicated structures and coherences.

Tesla's education started in primary schools of Smiljan and Gospic followed by 4 years at the middle school there. He finished middleschool in 1874 in Karlovac. Only after a critical Cholera disease his parents agreed that he might study physics, and so, in 1855, Tesla became a student at the "Kaiserlich-königliche Technische Hochschule in Graz" which is today the University of Technology in Graz. Only one year before Tesla registered the Polytechnic Institute, financed by the province of Styria, it was transferred to a Technical Hochschule which would be called nowadays a federal school. From 1878 on the "Kaiserlich-königliche Technische Hochschule in Graz" final examinations became "Staatprüfungen" (stately examinations). However, doctoral degrees could not be awarded before 1901.

But all this did not bother young Tesla. He left Graz without any degree after the Education Department of the "*K.K. Generalkommando in Agram* (Zagreb)", which administrated the Borderland, stopped the continuation of the stipend. The last recording in the registration reads: "*Wegen Nichtbezahlung der Unterrichtsgelder fuer das 1. Semester 1877/78 gestrichen*". Probably in order to avoid military service in the Austr-Hungarian monarchy he applied for financial support to the Serbian patriotic organization *Serbian Queen Bee* in Novi Sad on October 14, 1976. However, his request was rejected.

Tesla was an excellent student and in his annual report he had the best marks available even he had an interesting discussion with his professor in Experimental Physics. Prof. Poeschl was a well known professor of high reputation. In a lecture he demonstrated a Gramme machine which he had recently received when Tesla meant that a brushless motor would have much less spark generation and therefore less losses and noise. Poeschl answered that Tesla might be a very clever man, however, his ideas could never become reality because it would be equivalent to a *perpetuum mobile*.

Fig. 2 shows a photograph taken in those years either in Graz or Maribor.

Figure 2. Nikola Tesla

Much later, Tesla received the Honorary Doctorate from the *Technische und Montanistische Hochschule Graz* in 1937. That of the University in Vienna he had received already in 1908. Also in 1937 he was nominated for the Nobel Prize in Physics by the Viennese professor of Physics at the University of Vienna Felix Ehrenhaft (1879 – 1952).

Because of the lack of financial support Tesla left Graz without graduation and went for a short time to Maribor where he stayed from autumn of 1878 to March 1879. After almost one year in Gospic he went to Prague in 1880 following the request of his father to graduate from a university. He never graduated from the university there either and some biographers mention that he could not even register at the university because he did not speak Czech. However, the registry of the university in Prague show that Tesla was registered as an "external" studentattending lectures in analytical geometry and experimental physics.

When he felt that his parents had to make too great sacrifices for him he decided to be no longer a burden for them. He accepted a position at a Hungarian telephone company in Budapest. There, in February 1882, as a 25 years old man he had the innovative idea of the principles of rotating fields. 37 years later Tesla himself described it that the idea had enlightened him like a flash. It happened during a walk in the City Park of Budapest when the age of alternating current machines began. In this moment his further fate determined him to become an "engineer" and inventor whose genius even today seems to be an inexhaustible source for science and technology. Nevertheless, again and again his name became forgotten, however, popping up brilliantly periodically. This Symposium and all the events in connection with his 150th birthday are perfect opportunities to let Tesla's name shine as brilliant as it deserves.

In the same year of this important walk, in Budapest by recommendation of a friend he was offered a position at Continental Edison in Paris. There he experimented with rotary current field motors and built first models whenever he had the opportunity. In Summer of 1983, in Strasbourg he was successfully building the first operable motor without sliding contacts (brushes) and without commutator.

Encouraged by the director of Continental Edison and American friends in Paris he left Europe in June 1884 and joined Edison Machine Works in the United States. In 1891, when Tesla was 35 years old, he received the Citizenship of the United States of America. Until then all his inventions and all patents granted to him are achievements of a European living and working in the United States of America. At this time he was still a citizen of the Austro-Hungarian monarchy, and in particular a citizen of the Kingdom of Hungary.

His inventions and discoveries were pioneering in many areas. But already during his life time his personality was disputed and he was involved in many quarrels as far as his patents were concerned which all seemed to have been solved in his favour.

Already during the turn of the last century in many textbooks his name did not exist. Nowadays his name is remembered only by the Tesla transformer to generate high voltages at high frequency and by the measuring unit of the magnetic field. Also many of his patents are so much forgotten that today sometimes patents are issued which can be seen near those of Tesla's. Maybe Tesla himself contributed unconsciously to the loss of his high reputation by his patents applications and publications of his later years. Mostly the clarity of engineering thinking seems to be missing or are his ideas not understood yet? I do not dare to answer this question. Who knows what will be in the future and how many thoughts will be thought which Nikola Tesla had already thought.

What the application of his achievements in the future is concerned I would like to refer to what Niels Bohr once said: "*Predictions are very difficult to be made, in particular when they deal with the future*".

There are many open questions and open for speculations, like what Tesla meant by the *Death Rays*. Did he mean by it a corpuscular radiation? He was talking about these rays as a weapon, which will banish wars for ever? Unfortunately, however, in this case I believe he was absolutely wrong. Because with weapons wars are never avoided as soon as the other side possesses the same or equivalent weapons. I believe in Mahadma Ghandi's words: "*There is no way to peace, peace is the way*".

Another example is the *Free Energy* of Tesla which would help to solve the energy problem of the world. Is it just an illusion or had he already heard about the dark energy in space which plays an important role in cosmology nowadays?

After all the scientific community continues to be interested and mankind still benefits and even in the future will benefit from the numerous contributions to modern technology of this genius.

No doubt, his contributions changed the world and still are not out of date. They will help to keep on developing civilisation and the wellbeing of humanity.

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Appendix


Europe 1849
EUROPA
Kurt R. Richter
June 2006


Nationalities in k.k. Monarchy
BOHEMIA
MORAVIA
AUSTRIA
HUNGARY
TRANSYLVANIA
CROATIA-SLAVONIA
BOSNIA
BULGARIA
Distribution of Races in Austria-Hungary
Kurt R. Richter
June 2006

Nationalities

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June 2006

1943

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Education

1862 – 1866	Gospic	Elementary School
1866 – 1870	Gospic	Real Gymnasium
1870 – 1873	Karlovac	Gymnazia Karlvac
1873	Karlovac	Graduation
1875 – 1878	Graz	Techn. Hochschule
1880	Prague	University ?

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Polytechnic Institute
Raubergasse

Built 1665 – 1674
Benedictine Monastery

1811 – 1874
Polytechnic Institute

1874 – 1888
k.k. TH Graz

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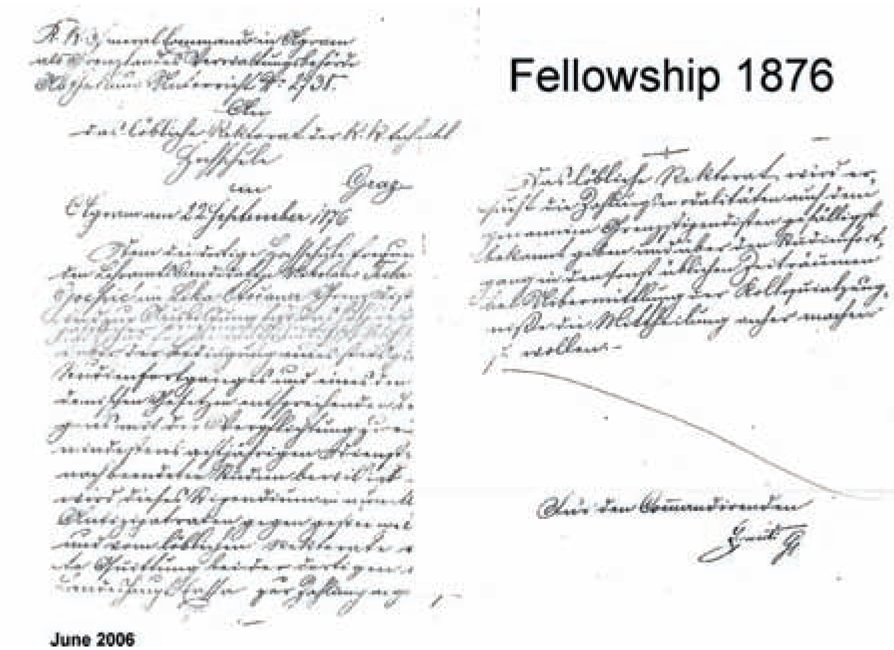
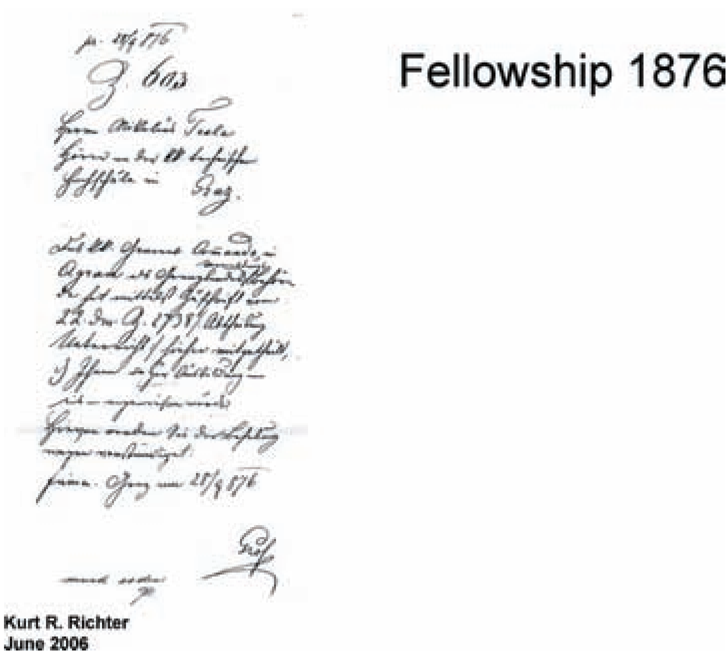

Fellowship 1876
June 2006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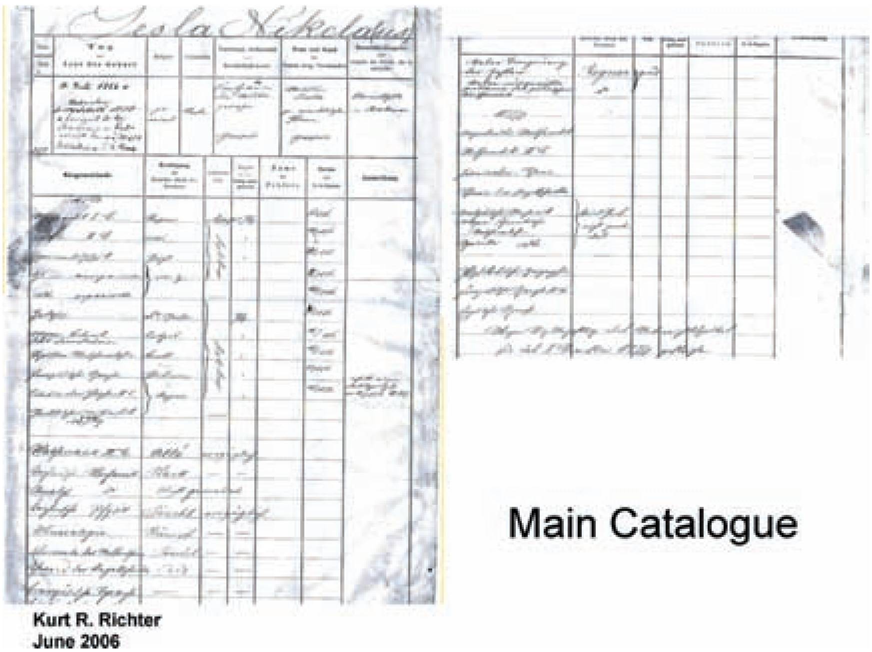
Kurt R. Richter
June 2006



1875/76

Lecture		hours	Professor
Mathematics I	7	Rogner	excellent
Mathematics II	7	Allè	excellent
Experimental Physics	5	Pöschl	excellent
Organic Chemistry	5	Maly	excellent
Inorganic Chemistry	5	Maly	excellent
Zoology	5	Graber	excellent
General Botanic incl. Demonstrations	3	Leitgeb	excellent
Mechanical Eng.	2	Bartl	excellent
French Languish	3	Plisnier	excellent
Cubature of Planes 2	2	Rogner	excellent
Political Arithmetic	2	Rogner	excellent

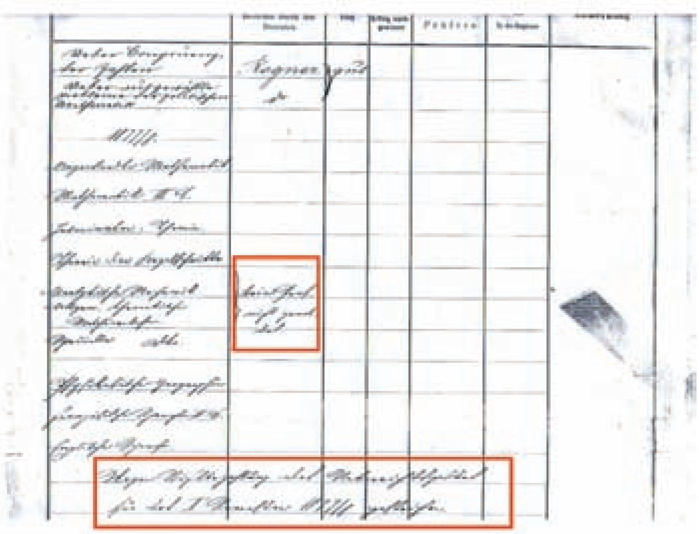
Kurt R. Richter
June 2006

1876/77

Lecture	hours	Professor	
Mathematics III	6	Allè	excellent
Technical Mech.	5	Stark	excellent
Analytical Mech.	2	Stark	No registration
Technical Physics	3	Pöschl	excellent
Mineralogy	3	Rumpf	–
Elements of Wave theory	2	Pöschl	–
Theory of Conic Sections	2	Pelz	–
French II	2	–	–
English	4	–	–
On Congruencies of Numbers	2	Rogner	o.k.
Problems in Political Arithmetic	2	Rogner	o.k.

Kurt R. Richter
June 2006

Last Year in Graz



Kurt R. Richter
June 2006

Request for Information

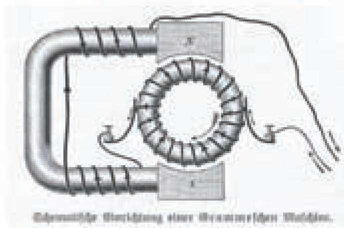
Tesla's Professional Activities

1879	Maribor, Technician
1881 – 1882	Budapest, Telephone Company
1882 – 1883	Paris, France, Continental Edison Company
1883 – 1884	Strasbourg, France
1884	Emigration to US
(1891)	(US Citizenship)

Kurt R. Richter
June 2006

A Crucial Experience

Grammé Machine



Kurt R. Richter
June 2006

Nikola Tesla and Jakob Pöschl

When in an experimental lecture in physics Tesla proposed an improvement of the Grammé machine demonstrated by Prof. Pöschl, the latter stated:

"Mr. Tesla may accomplish big things but in this he never will be successful. This would be similar to divert a continuous attraction like gravity into a rotating movement. It would be a Perpetuum Mobile. An impossible idea."

Kurt R. Richter
June 2006

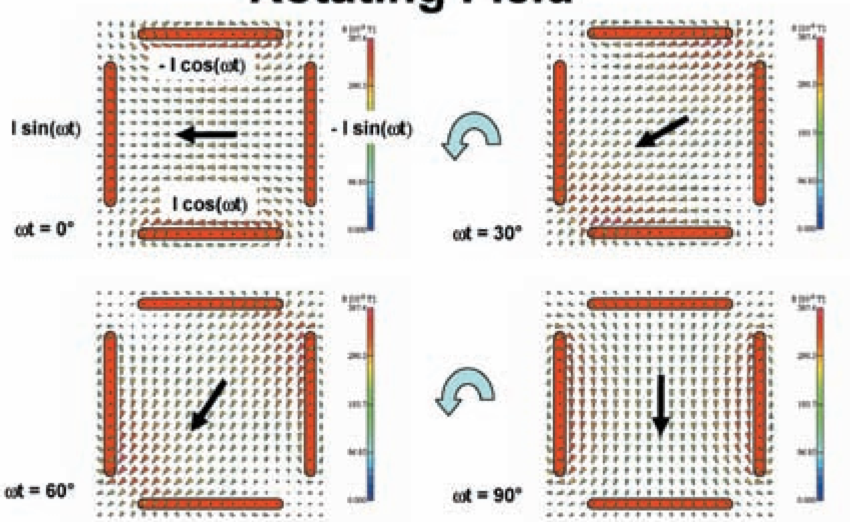
Budapest City Park Experience

…… the idea came like a flash of lightening and in an instant the truth was revealed. ……
……The images I saw were wonderfully sharp and clear and had the solidity of metal and stone, ……
……… I cannot begin to describe my emotions. Pygmalion seeing his statue come to life could not have been more deeply moved. A thousand secrets of nature which I might have stumbled upon accidentally, I would have given for that one which I had wrested from her against all odds and at the peril of my existence.......

My Inventions: Autobiography of Nikola Tesla

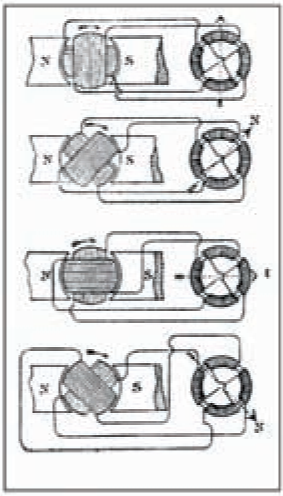
Kurt R. Richter
June 2006

Rotating Field



Kurt R. Richter
June 2006

Tesla Motor

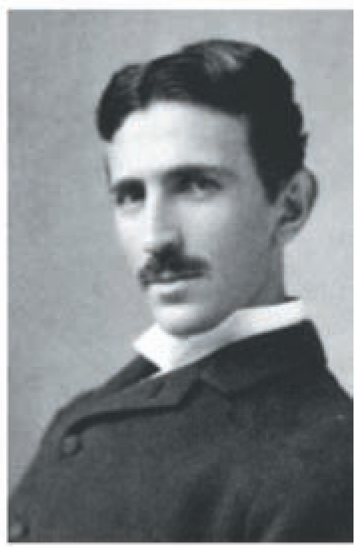


Reconstruction in Tesla Museum, Belgrade
and in Deutsches Museum, Munich

Kurt R. Richter
June 2006

Tesla (about 1884)

1884
The year of emigration
to the
United States of America



Kurt R. Richter
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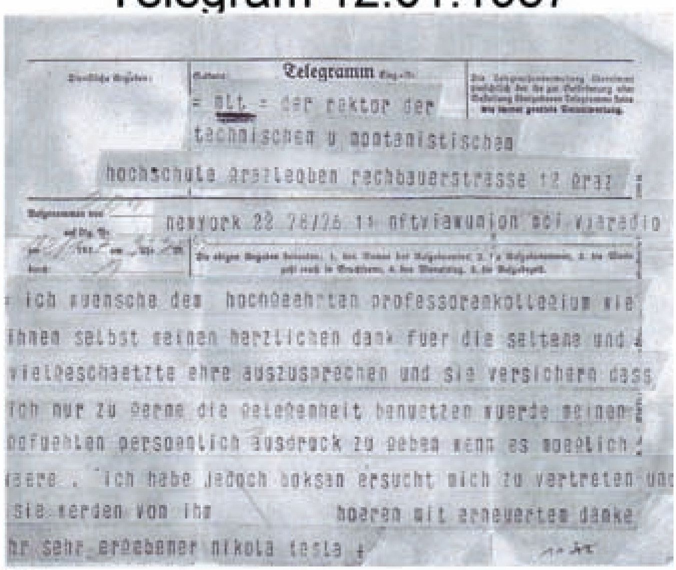
Doctor honoris causa

University of Paris
Vienna Polytechnic Institute
University de Poitiers
University of Beograd
Techn. Hochschule Graz
University of Brno
University of Zagreb
Polytechnic Institute of Bucharest
University of Grenoble
University of Sophia
University of Prague

Columbia University
Yale University

Kurt R. Richter
June 2006

Telegram 12.01.1937



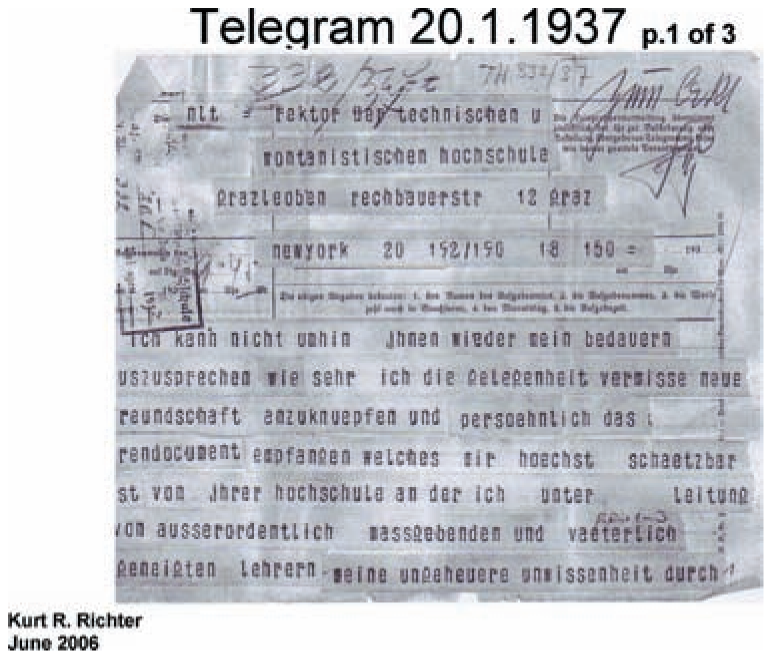
Telegramm

= dlt = der rektor der
technischen u montanistischen
hochschule grazleoben rechbauerstrasse 12 graz

newyork 22 78/76 11 nftviawunion nci viaradio

= ich wuensche dem hochgeehrten professorenkollegium wie
ihnen selbst meinen herzlichen dank fuer die seltene und
vielgeschaetzte ehre auszusprechen und sie versichern dass
ich nur zu gerne die gelegenheit benuetzen wuerde meinen
gefuehlen persoenlich ausdruck zu geben wenn es moeglich
waere . ich habe jedoch boksan ersucht mich zu vertreten und
sie werden von ihm hoeren mit erneuertem danke
ihr sehr ergebener nikola tesla +

Kurt R. Richter
June 2006


Telegram 20.1.1937 p.1 of 3

nlt = rektor der technischen u
montanistischen hochschule
grazleoben rechbauerstr 12 graz
newyork 20 152/150 18 150 =

ich kann nicht umhin ihnen wieder mein bedauern
uszusprechen wie sehr ich die gelegenheit vermisse neue
reundschaft anzuknuepfen und persoehnlich das
rendocument empfangen welches mir hoechst schaetzbar
st von ihrer hochschule an der ich unter leitung
von ausserordentlich massgebenden und vaeterlich
geneigten lehrern meine ungeheuere unwissenheit durch

Kurt R. Richter
June 2006


Kraft des den Technischen Hochschulen erteilten Rechtes verleiht über einstimmigen Beschluß des Professorenkollegiums und mit Ermächtigung der Bundesregierung die Technische und Montanistische Hochschule Graz-Leoben zu Graz unter dem Rektorate von

Dr. techn. Architekt Friedrich Zotter
o. ö. Professor für Baukunst

Herrn Ingenieur
Nikola Tesla
Dr. techn. e. h. etc.

in Anerkennung seiner überragenden Verdienste um die Entwicklung der Mehrphasenstrom-Maschinen- und der Hochfrequenz-Technik

den Titel und die Würde eines
Doktors der technischen Wissenschaften
ehrenhalber
samt allen damit verbundenen Rechten.

Urkund dessen wurde dieses Diplom ausgefertigt
Gegeben zu Graz, am 23. Jänner 1937.

Der ordnungsgemäß bestellte Promotor	Der Rektor	Der Dekan der Fakultät für angewandte Mathematik und Physik

Certificate

Kurt R. Richter
June 2006

Awards

- 1893 The Franklin Institute's **Elliott Cresson Gold Medal**
- 1916 AIEE (IEEE) **Edison Medal**
- 1934 **John Scott Medal**
- 1937 Nomination for an **undivided Nobel Prize** (by Prof. Felix Ehrenhaft, University of Vienna)

Kurt R. Richter
June 2006

Quotes

Niels Bohr (1885 – 1962), Danish Physisist

"Prediction is very difficult, especially about the future."

Nikola Tesla:

"Let the future tell the truth, and evaluate each one according to his work and accomplishments. The present is theirs; the future, for which I have really worked, is mine."

Kurt R. Richter
June 2006

Wardencliff Tower

Kurt R. Richter
June 2006

Societies of the Institute of Electrical and Electronic Eng. (IEEE)

Aerospace and Electronic Systems
Antennas and Propagation
Broadcast Technology
Circuits and Systems
Communications
Components, Packaging, and Manufacturing Technology
Computational Intelligence
Computer
Consumer Electronics
Control Systems
Dielectrics and Electrical Insulation
Education
Electromagnetic Compatibility
Electron Devices
Engineering Management
Engineering in Medicine and Biology
Geoscience and Remote Sensing
Industrial Electronics
Industry Applications
Information Theory
Instrumentation and Measurement
Intelligent Transportation Systems
Lasers and Electro-Optics
Magnetics
Microwave Theory and Techniques
Nuclear and Plasma Sciences
Oceanic Engineering Power Electronics
Power Engineering
Product Safety Engineering
Professional Communication
Reliability
Robotics and Automation
Signal Processing
Social Implications of Technology
Solid-State Circuits
Systems, Man, and Cybernetics
Ultrasonics, Ferroelectrics, and Frequency Control
Vehicular Technology

Kurt R. Richter
June 2006

Tesla's inventions contributed to 50% of the fields covered by the 38 IEEE Societies

Contemporaries of Tesla

Lord Kelvin (1824 – 1907)
"Tesla has contributed more to *electrical science* than any man up to his time."

Hermann v. Helmholtz (1821 – 1894)
Conversation of Force (Energy)

Sir William Crookes (1832 – 1919) Radiometer

Sir James Dewar (1842-1923) Dewar-vessel

Ernest Rutherford (1871-1937) Nuclear physics

Ernst Werner v. Siemens (1816-1892)

James Clark Maxwell (1831-1879)

Ludwig Boltzmann (1844-1906)
Thermodynamics

Noble Prize winners

John Rayleigh (1842-1919) 1904

Sir William H. Bragg (1862-1942) 1915

Sir William L. Bragg (1890-1971) 1915

Max Plank (1858-1947) 1918

Albert Einstein (1879-1955) 1921

Niels Bohr (1885-1962) 1922

Robert Millikan (1868-1953) 1923

Compton (1892-1962) 1927

Sir Edward Appleton (1892-1965) 1947

Kurt R. Richter
June 2006

Tributes to Nikola Tesla

Lord Kelvin: "Tesla has contributed more to *electrical science* than any man up to his time.„

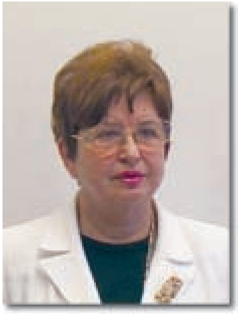
Niels Bohr: "With deepest admiration we think of how Tesla could accomplish such great achievements.„

W.H. Bragg: "[Dr. Tesla's] experiments were the most original and daring... I shall never forget."

Arthur Holly Compton: "Tesla is entitled to the enduring gratitude of mankind."

Albert Einstein: "[Tesla is] an eminent pioneer in the realm of high frequency currents... I congratulate [him] on the great successes of [his] life's work."

Kurt R. Richter
June 2006



Prof. **Branka Zovko-Cihlar**, Ph.D.
Faculty of Electrical Engineering and Computing,
University of Zagreb, Zagreb, Croatia
e-mail: branka.zovko@fer.hr

From Tesla's Inventions in the Field of Radiocommunications to Digital Broadcasting for Multimedia Services[1]

Abstract

In the early days of Tesla's research he explained the process of electromagnetic waves propagation. His experimentations with high frequencies, wireless communication systems, and high frequency oscillator are the base of transmission technology today. In this paper the influence of Tesla's inventions and results in the field of radiocommunications are described.

Key words

Nikola Tesla, inventions, radiocommunications, digital video broadcasting

1. Introduction

Nikola Tesla was genius, whose discoveries in the field of alternating polyphase current electricity advanced whole world and explored and developed many of fundamental concept of modern technology. Tesla had imaginations and intuitive way of developing new ideas on scientific base.

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[1] Reprinted from *Symposium "Tesla in Croatia": Proceedings*, Croatian Academy of Engineering, ISBN 953-7076-10-5, 2006.

Nikola Tesla was born on July 10, 1856 in the village Smiljan (near town Gospic, Lika), Republic of Croatia, in a Serbian family. Now we celebrate 150th anniversary of the birth of Nikola Tesla. Tesla finished his school in Karlovac and then studied electrical engineering at the Austria Polytechnic in Graz from 1875. In 1882 he moved to Budapest and worked for telegraph company (American Telephone Company). In 1882 he moved to Paris, France to work as an engineer for the Continental Edison Company. In 1884, Tesla arrived in United States of America and started to work in company Edison Machine Works, which produced direct current generators. His work in Edison Company resulted in differences in ideas between Edison and Tesla, because Edison did not want to accept Tesla's ideas that alternating current is better solution. 1885 George Westinghouse, founder of Westinghouse Electric Company in Pittsburg, bought patent rights for Tesla's alternating current systems.

In 1886, Tesla formed his own company: "Tesla Electronic Light & Manufacturing" with the plan for an alternating current motor. In 1887 he constructed the initial brushless alternate – current induction motor, and he demonstrated it in 1888 to the American Institute of Electrical Engineers (IEEE).

In 1888 Tesla started to work with George Westinghouse at Westinghouse Electric & Manufacturing Company in Pittsburg, USA, where he started with idea for polyphase systems which would allow transmission of alternating current electricity over the large distances. In 1888, in Westinghouse labs, Tesla had obtained patents on a whole polyphase system of a current dynamos, transformers and motors.

Tesla explained the principles of rotating magnetic field and induction motor by demonstrating how to make a cooper egg stand on end. This phenomenon, which he constructed, is known as the "Egg of Columbus".

In 1897 Tesla demonstrated a radio controlled boat to the US military, believing that the military would want use this invention for radio controlled torpedoes. In the filed of radiocommunications, 1898 radio controlled boat was demonstrated to the public during an electrical exhibition at Madison Square Garden and this radio remote control remained a novelty until 1960.

Between 1895-1899, Tesla designated the first hydro-electric power plant at Niagara Falls and this was the final victory of Tesla's alternating current over Edison's Direct Current, Fig. 1.

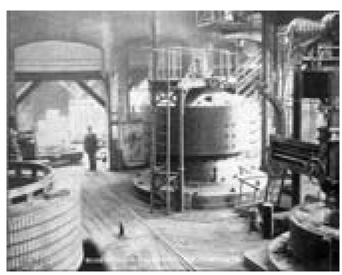


Figure 1. Nikola Tesla designed the first hydro-electric power plant at Niagara Falls (1895-1899)

During the next period of Tesla's work in his New York laboratories he made a research on wireless communications. The result of wireless transmission of electricity through ionosphere was Wardenclyffe Tower with electrical sparks for transfer electricity without wires. This was the first broadcasting system in the world, Fig. 2.

Figure 2. Tesla's Wardenclyffe Tower located in Shoreham, Long Island, New York, USA

Tesla wanted to transmit electricity from this tower to the whole globe. The source of the transmitted electricity was from the Niagara Falls power plant.

Tesla with his invention fundamentally changed the world. As Margaret Chaney said in Tesla's biography, he was “The Man out of Time”.

2. Tesla's Inventions in the Field of Radiocommunications

Tesla's started with experiments to explore himself a phenomenon of high frequency electricity. In England in 1873 Maxwell theoretically predicted electromagnetic waves. Maxwell found mathematically that light could be electromagnetic wave which he defined with very well known “Maxwell equations”. In 1888 Heinrich Hertz confirmed with experiments that an electric spark propagates electromagnetic waves into space. This result in a fact that electromagnetic waves could exist at all frequencies. Some years later Tesla presented wireless communication system at lower frequencies which made long distance communication possible. Today we know that electromagnetic waves penetrate deep into space and we can see television signal which was transmitted from the Moon to the Earth.

Figure 3. Illuminated gas – field phosphor coated light bulb

Tesla continued with experiments with high frequencies and in 1890 he illuminated vacuum tube by wireless transmission of energy through the air, Fig. 3. Tesla was holding

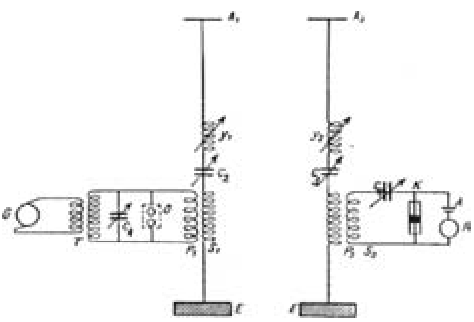
Figure 4. Experimental Station at Colorado Springs where the first wireless transmission experiments were preformed (1899-1900)

a gas field phosphor coated light bulb which was illuminated without wires by electromagnetic field from Tesla coil.

In 1891 Tesla patented Tesla coil with frequency sixty – cycle per second and stepped it up to extremely high frequency. Tesla coil could also generate extremely high voltages. In 1899 Experimental Station in Colorado Springs was design, where the wireless transmission experiments were performed, Fig. 4.

Nikola Tesla explained a wireless communication system – Tesla oscillator, Fig. 5. With Tesla coils he was able to transmit and receive powerful radio signals when the coils were tuned to the same frequency.

In Fig. 5, generator G and transformer T is power supply for transmitter. Resonant circuit C1 and P1 initiated by the spark oscillator to the resonant frequency of about 100 kHz. Antenna was vertical wire with the small capacity on the top. At 100 kHz antenna has high impedance. Oscillator is high frequency generator with small impedance. There exist mismatch between antenna impedance as a load and impedance of oscillator as a source. Because of this phenomena Tesla found the solution with his Tesla high frequency transformer which he connect between antenna and oscillator. Transformer's secondary coil with inductance Y1 and capacity C2 make the resonant circuit, which resulted in the impedance match between the load and source.



G – generator
A1 – transmitter's antenna
T – transformer
O – spark oscillator
C1, C2 – capacitors
Y1 – inductance
P1 – primary coil
A2 – receiver's antenna
S1 – secondary coil
K – dector (coherer)

Figure 5. Tesla oscillator

Tesla transformed the high current of the oscillator into a low current with high voltage in the transmitter's antenna and this solution is still in use and all broadcasting transmitters work on this principle. On the receiver side antenna has Tesla transformer to match the impedance of the antenna to the detector, which gives us the received signal.

In reality Tesla invented radio and not Marconi, and holds the original patent for his development.

In 1918 started electronic age and high frequency current could be generated by help of control – grid high – vacuum tubes, making higher frequencies possible. On this invention around 1924 the amplitude modulated radiocommunication signal with high frequency was possible which we still have today in the broadcasting transmission.

At the end of 20th century digital signal transmission started, and this new technology enabled development of mobile systems, computer technology, digital television broadcasting and multimedia services transmission.

3. Digital Video Broadcasting System

Standard for digital terrestrial broadcasting DVB-T started in 1990 in Europe. First important decision was selection of MPEG-2 for source coding of audio and video data at the input of digital video transmitter.

Multimedia services in future will require the transmission of very high data rates over broadband radio channels. The European terrestrial digital TV system continues its progression among the broadcaster community around the world. The interest for new services to sustain its successful technical and commercial deployment grows tremendously. The market introduction by the DVB-T forum of the Multimedia Home Platform (MHP) provides the broadcasters with terminal able to implement many categories of interactive new services. For multimedia data transmission is of great importance to distribute digital video signal with high quality of service – QoS, large amplifier efficiency and with nominal transmitter output power. With this requirement the main role is method of suppression non-linearity products in terrestrial digital video transmitter with apply of digital precorrection unit and output filter unit. Standard for digital terrestrial broadcasting DVB-T, established in 1997, opened a new era in digital TV technology for multimedia. Multicarrier techniques, COFDM modulation, digital precorrection GPS synchronization, are some of the features of a digital transmitter. COFDM modulation method is very resistant to different disturbances (e.g. reflection and interference), and also spectrally economical, enabling the multimedia transmitter network to transmit the digital signal on only one channel.

Input signal to the transmitter is a MPEG-2 transport stream, with 5 Mbit/s to 34.3 Mbit/s data rate, depending on transmission mode and parameters chosen, Fig. 6.

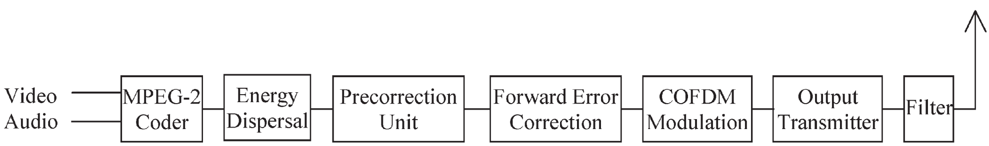


Fig. 6

To obtain OFDM signal, transport stream is divided into two (QPSK), four (16QAM) or six (64QAM) bit streams, forming a word of 2, 4 or 6 bits, defining the subcarrier vector. OFDM symbol is in 8K mode formed by 6817 subcarriers, and in 2K mode by 1705 subcarriers. Symbol duration is divided into two parts: useful and guard parts. Guard part can occupy 1/4, 1/8, 1/16 or 1/32 of the whole symbol duration.

In linear precorrection unit the input I/Q stream is treated in amplitude and phase to linearise the power-amplifier transfer characteristics.

Up-converter converts the IF signal to the desired UHF channel, which will be amplified for driving the output stage to the level needed.

Filter unit at the output of DVB-T transmitter is a two port network which allows power within defined frequency range to be transferred from the power amplifier to the antenna load, while in other frequency ranges it prevents almost all the power from passing to the load.

Filter Characteristic Specification

Standard EN 300 744 prescribes the spectral mask, which has to be filled by digital TV transmitter. Based on the prescribed mask and the frequency spectrum characteristics of the DVB-T signal at the amplifier output, selectivity needed of the filter unit together with other filter parameters is evaluated.

According to the filter specification as a frequency range, frequency bandwidth, insertion loss, output power, we can choose coaxial l/4 filters from 200 MHz up to 1 GHz.

Here is a short definition of filter parameters:

The **bandwidth** of band pass filter is defined as the frequency difference between the upper and lower –3 dB points (*cut-off frequencies*). However, if a pass band gain variation (i.e., 1 dB) is specified, the cut-off frequencies will be the frequencies at which the maximum gain variation specification is exceeded.

Insertion loss of filter is the ratio between the output power Pout and the input power Pin, defined as

$$\text{Insertion loss} = 10\log\left(\frac{P_{\text{out}}}{P_{\text{in}}}\right)\ [\text{dB}] \tag{3}$$

The output power of the filter is smaller than the input power, making the ratio in Eq. (4.1) less than one and the attenuation is a negative number.

Group Delay is defined as the derivative of a filter's phase with respect to frequency,. For an ideal filter, the phase will be linear and the group delay would be constant. Group delay, whose unit of measure is time in seconds, can also be thought of as the propagation time delay of the envelope of an amplitude modulated signal as it passes through a filter. Group delay distortion occurs when signals at different frequencies take different amounts of time to pass through a filter

$$\tau_{\text{g}} = -\frac{\mathrm{d}\varphi}{\mathrm{d}\omega} = -\frac{1}{2\pi}\frac{\mathrm{d}\varphi}{\mathrm{d}f} \tag{4}$$

Transfer Filter Characteristic

In circuit theory, a filter is an electrical network that alters the amplitude and phase characteristics of a signal with respect to frequency. Ideally, a filter will not add new frequencies to the input signal, nor will it change the component frequencies of that signal, but it will change the relative amplitudes of the various frequency components and their phase relationships. The frequency-domain behaviour of a filter is described mathematically in terms of its transfer function. This is the ratio of the Laplace transforms of its output and input signals. The voltage transfer function H(p) of a filter can be written as:

$$H(p)=\frac{L[Y(t)]}{L[X(t)]}=\frac{Y(p)}{X(p)} \tag{5}$$

where p is complex frequency variable.

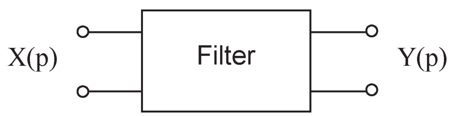


Figure 7. Filter as two port network

The generalized transfer function is defined by:

$$H(p)=K\frac{a_0+a_1p+a_2p^2+\ldots+a_np^n}{b_0+b_1p+b_2p^2+\ldots+b_np^n}=K\frac{P(p)}{Q(p)}, \tag{6}$$

where a_n, b_n are polynomials coefficient, p = complex frequency, $P(p)$ and $Q(p)$ polynomials of n-th, and m-th order.

By factoring the numerator and denominator polynomials this may be written as:

$$H(p)=\frac{K(p-p_{01})(p-p_{02})\ldots(p-p_{0m})}{(p-p_{x1})(p-p_{x2})\ldots(p-p_{xn})}. \tag{7}$$

At the frequencies $p = p_{01}, p_{02}, \ldots p_{0m}$, where the numerator polynomial goes to zero the transfer function will be zero, and this frequencies are known as the zeros of the function. At the frequencies $p = p_{x1}, p_{x2}, \ldots p_{xm}$, where the denominator polynomial is zero the transfer function will have the maximum value; this frequencies are known as the poles of the function.

The concepts of complex frequency and poles and zeros are very helpful in network analysis and design.

Methods of Filter Design

According to the filter specification as a frequency range, frequency bandwidth, insertion loss, output power, we can choose one of three basic filter designs.

- helical filter
- coaxial l/4 filter
- waveguide filter

Each this filter structure is dominant in specific frequency range. Helical filters for high power will be used in the frequency range up to 300 MHz, coaxial l/4 filters from 200 MHz up to 1 GHz, and waveguide filter upper of 1 GHz.

Fig. 8 shows a form of coaxial resonator which operates in the transverse electromagnetic (TEM) mode and is a quarter-wavelength long at resonance. One end of resonator is open-circuited while the other is short-circuited, and tuning is accomplished by sliding the round centre conductor back and forth through the short-circuited region of resonator.

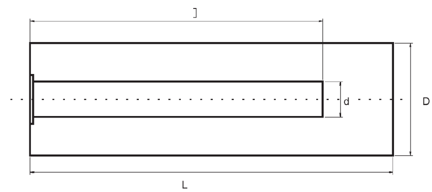


Figure 8. Coaxial l/4 resonator

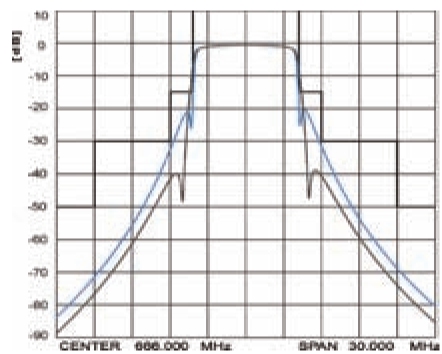


Figure 9. Simulation of filter characteristic with 6 cavities and a) two notch cavities, b) cross coupling

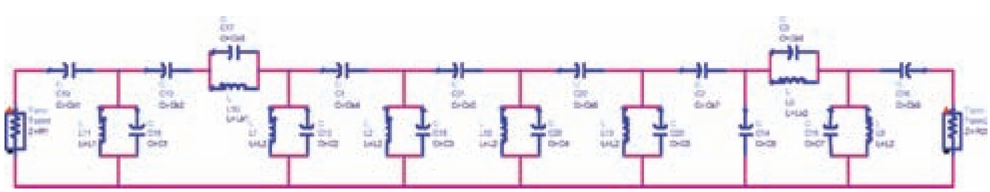


Figure 10. Filter circuit with six resonator cavities and two notch coupling

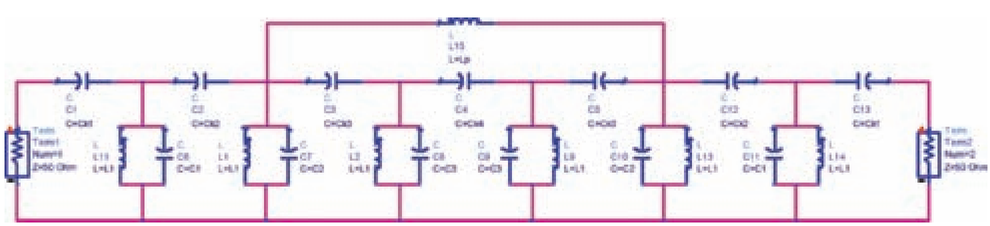


Figure 11. Filter circuit with six resonator cavities and cross coupling

4. Digital video broadcasting on handhelds (DVB-H)

Digital Video Broadcasting – Terrestrial (DVB-T), the current standard in digital video broadcasting, wasn't designed for mobile devices. However, as antenna technology improved, DVB-T mobile services became feasible, leading to extensive commercial trials. Digital TV reception on the move is an exciting advance in broadcasting.

However, handheld devices simply don't have the battery life to make DVB-T reception a viable option for consumers. A new solution was needed, DVB-H, or Digital Video Broadcast – Handheld, is that solution.

In addition to a great reduction of battery power consumption, DVB-H had other major requirements: maximum compatibility with DVB-T systems and networks, as well as the ability to receive 15 Mbit/s in an 8 MHz channel and in a wide area single frequency network at high speed.

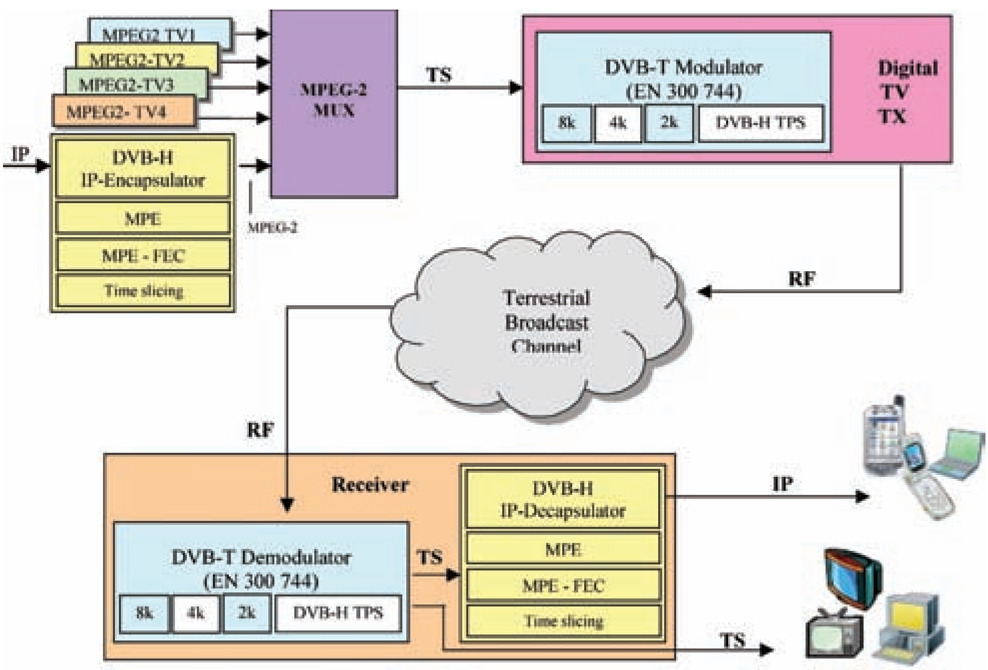


Figure 12. A conceptual description of using a DVB-H system

6. Conclusion

Today DVB-T is the most popular digital terrestrial television system in the world, adopted in more countries than any other. It has been successfully deployed in the UK, Germany, Sweden, Finland, Spain, Italy the Netherlands, Switzerland, Singapore and Australia. DVB-T trials are on-going in China, Malaysia, Thailand, Vietnam, Ukraine, Croatia, South Africa and others.

DVB-H is the latest development from the DVB Project targeting handheld, battery powered devices such as mobile telephones, PDAs, etc. Based on DVB-T excellent mobile performance, it answers need to ensure reliable, high speed, high data rate reception.

DVB-H combines broadcasting with a set of measures to ensure that the target receivers can operate from a battery and on the move, and is thus an ideal companion to 3G telecommunications, offering symmetrical and asymmetrical bi-directional multimedia services.

Intermodulation products caused by output power amplifier non-linearities could be lowered to a great extent using a sufficiently large output backoff. That would mean a considerable amplifier efficiency factor drop, being uneconomical. As a compromise, the output backoff lowering is suggested to the extent, needed for the sum of IM products from output amplifier, of linear precorrection and of output filter unit to reach the value prescribed by EN 300744 standard for output spectral mask. For multimedia services is possible to distribute in frequency channel range (6, 7 or 8 MHz) four digital video signals with high quality or six digital video signals with lower quality.

Harris Broadcast Corporation Division attended award ceremony at the RAI Centre on IBC 2005 in Amsterdam with its new DVB-R Liquid Cooled Output Filter 5kW/UHF. Harris Broadcast Corporation received at IBC 2005 “Product of the Year” award by Cable and Satellite International. This filter was designed by Dr. Ivan Milak who received PhD degree with this work at the University of Zagreb, Faculty of Electrical Engineering and Computing, and his supervisor was Professor Branka Zovko-Cihlar, PhD.

All what Tesla foresee based on the development, experiments, patents from the field of high frequency we have today is result in his invention. All invention like alternating current, Tesla AC motors, Tesla coil, Tesla transformers, long distance current transportation, Tesla oscillator and many other innovation we used today.

All this new technology was Nikola Tesla's dream and this dream is now reality.

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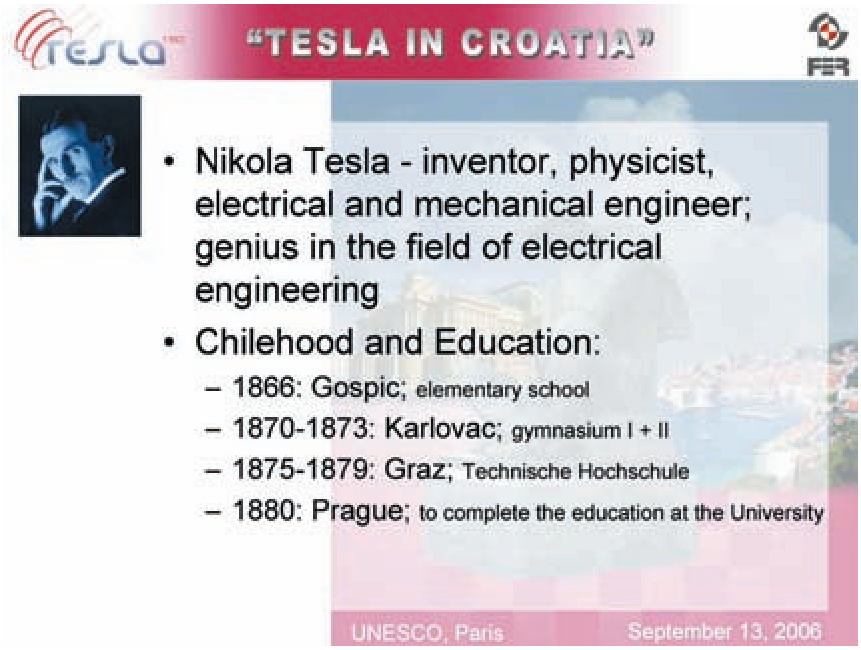
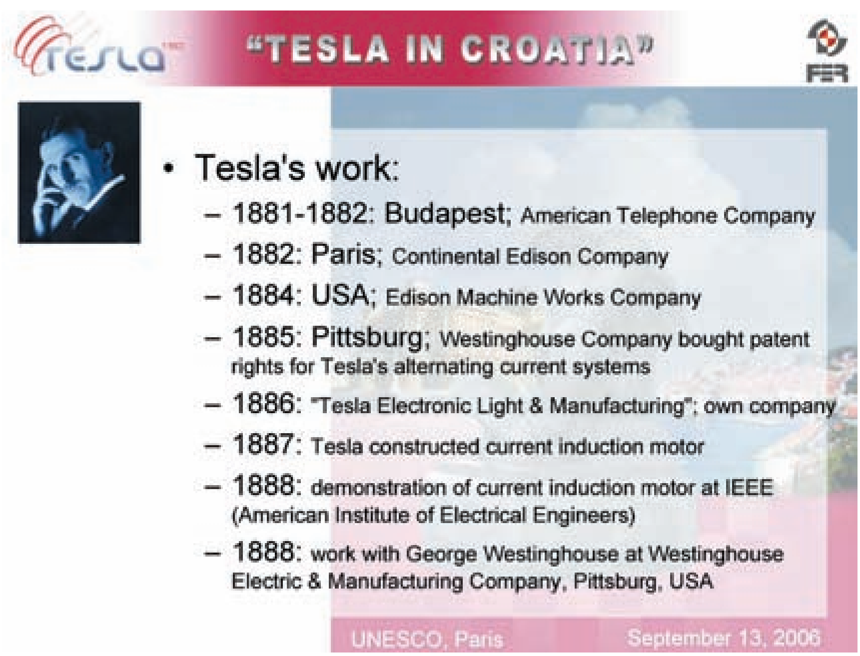
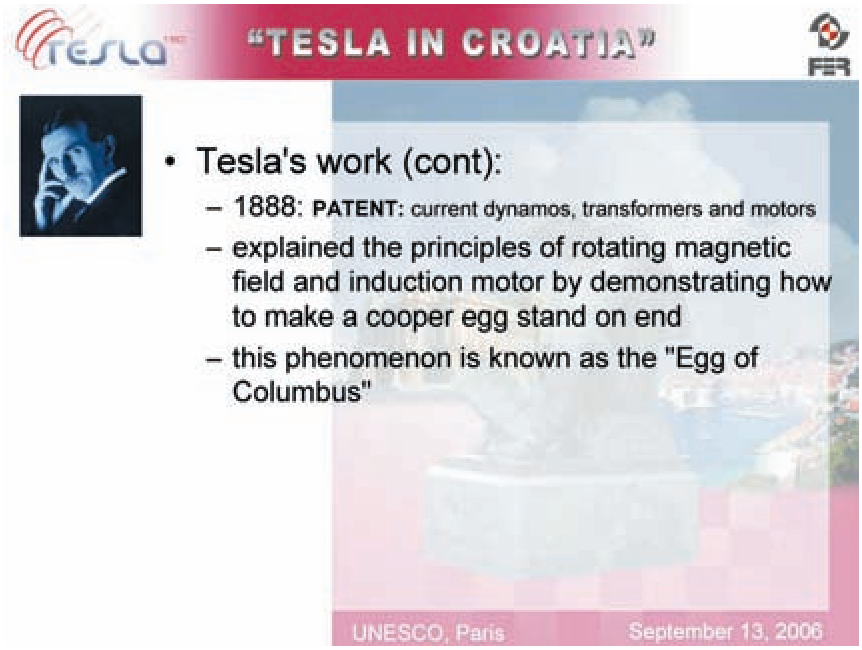
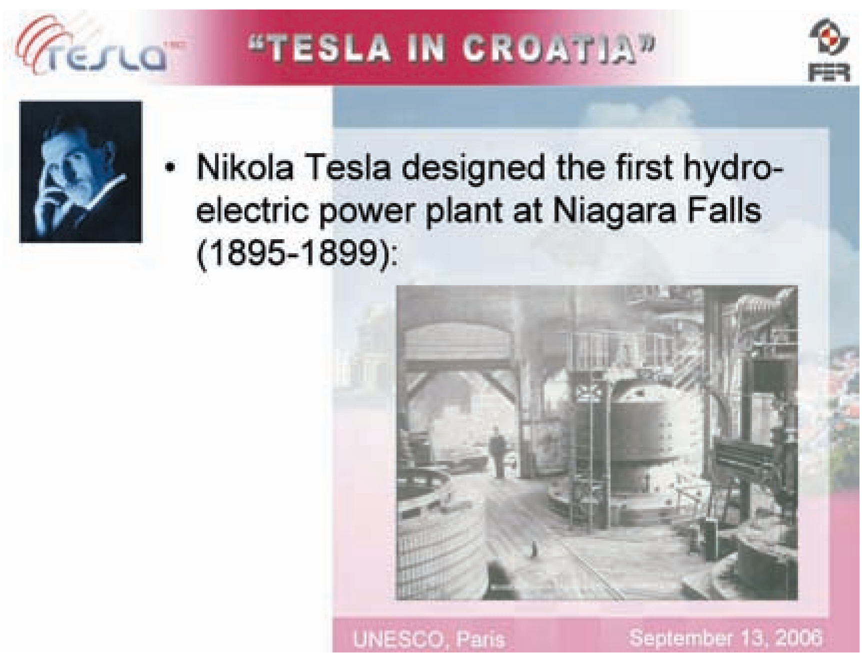
7. Zovko-Cihlar, B., From Tesla's Inventions in the Field of Radiocommunications to Digital Broadcasting for Multimedia Services, Proceedings of the International Scientific and Professional Meeting “The Life and Work of Nikola Tesla”, Zagreb, Croatia, 28-29 June 2006, pp. L14

Appendix


"TESLA IN CROATIA"
FER
• Nikola Tesla - inventor, physicist, electrical and mechanical engineer; genius in the field of electrical engineering
• Chilehood and Education:
– 1866: Gospic; elementary school
– 1870-1873: Karlovac; gymnasium I + II
– 1875-1879: Graz; Technische Hochschule
– 1880: Prague; to complete the education at the University
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
• Tesla's work:
– 1881-1882: Budapest; American Telephone Company
– 1882: Paris; Continental Edison Company
– 1884: USA; Edison Machine Works Company
– 1885: Pittsburg; Westinghouse Company bought patent rights for Tesla's alternating current systems
– 1886: "Tesla Electronic Light & Manufacturing"; own company
– 1887: Tesla constructed current induction motor
– 1888: demonstration of current induction motor at IEEE (American Institute of Electrical Engineers)
– 1888: work with George Westinghouse at Westinghouse Electric & Manufacturing Company, Pittsburg, USA
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
• Tesla's work (cont):
– 1888: PATENT: current dynamos, transformers and motors
– explained the principles of rotating magnetic field and induction motor by demonstrating how to make a cooper egg stand on end
– this phenomenon is known as the "Egg of Columbus"
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
• Nikola Tesla designed the first hydro-electric power plant at Niagara Falls (1895-1899):
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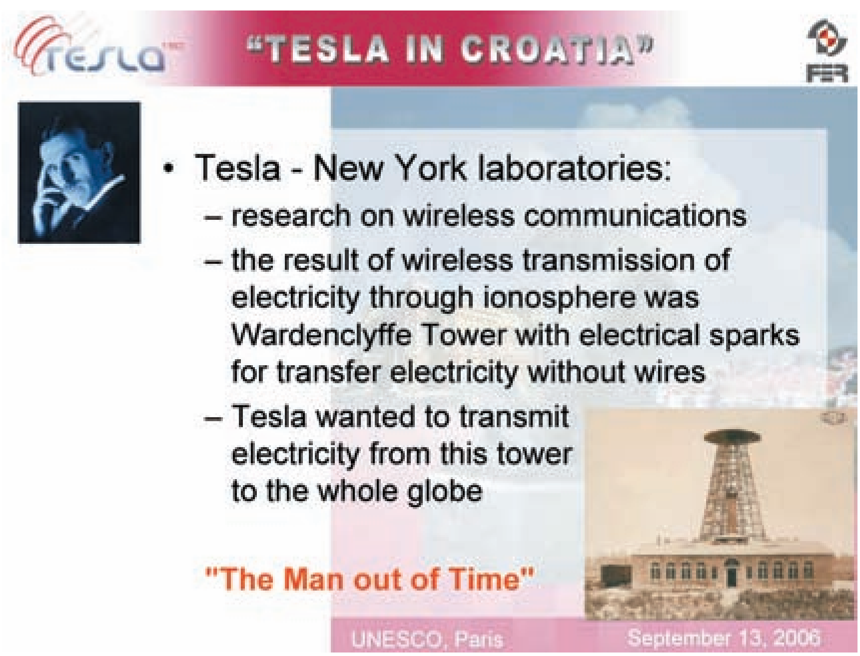
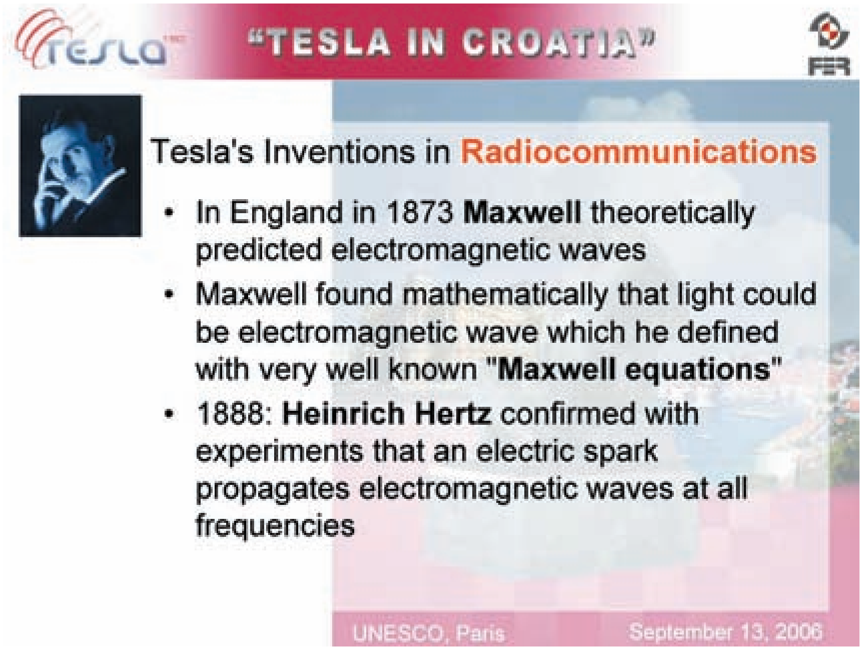
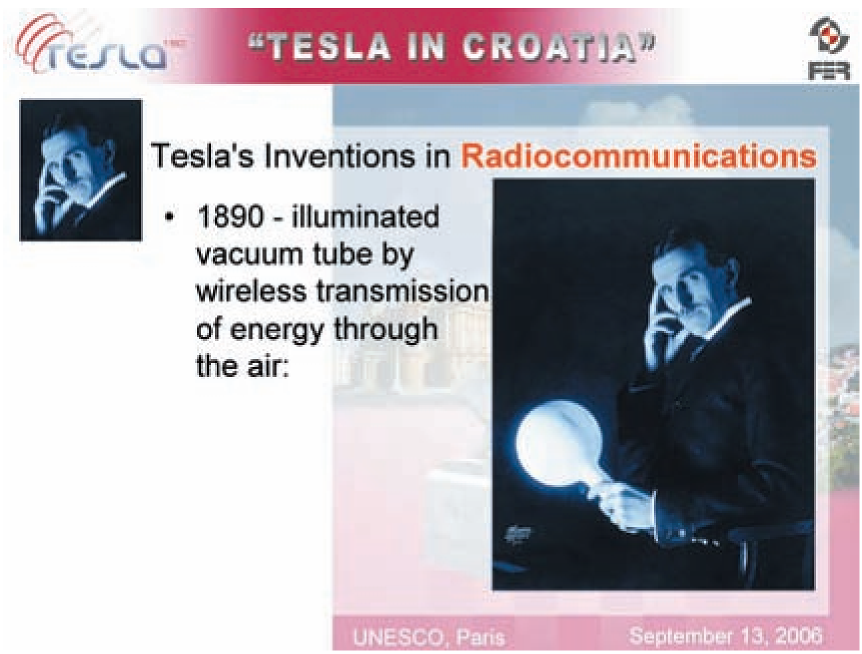
tesla
"TESLA IN CROATIA"
FER
• in the field of radiocommunications - 1898:
– radio controlled boat was demonstrated to the public during an electrical exhibition at Madison Square Garden
UNESCO, Paris
September 13, 2006


tesla
"TESLA IN CROATIA"
FER
• Tesla - New York laboratories:
– research on wireless communications
– the result of wireless transmission of electricity through ionosphere was Wardenclyffe Tower with electrical sparks for transfer electricity without wires
– Tesla wanted to transmit electricity from this tower to the whole globe
"The Man out of Time"
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
Tesla's Inventions in Radiocommunications
• In England in 1873 Maxwell theoretically predicted electromagnetic waves
• Maxwell found mathematically that light could be electromagnetic wave which he defined with very well known "Maxwell equations"
• 1888: Heinrich Hertz confirmed with experiments that an electric spark propagates electromagnetic waves at all frequencies
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
Tesla's Inventions in Radiocommunications
• 1890 - illuminated vacuum tube by wireless transmission of energy through the air:
UNESCO, Paris
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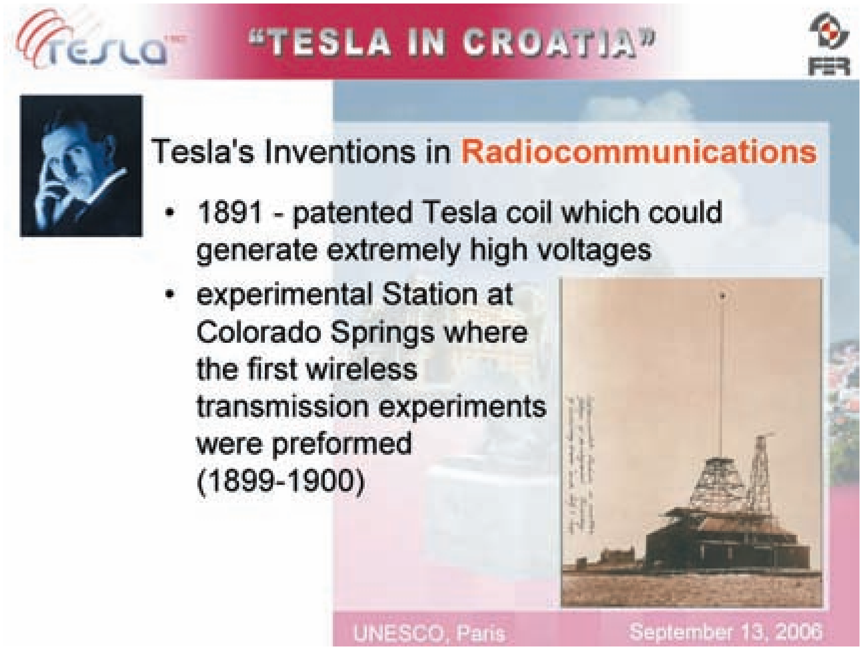
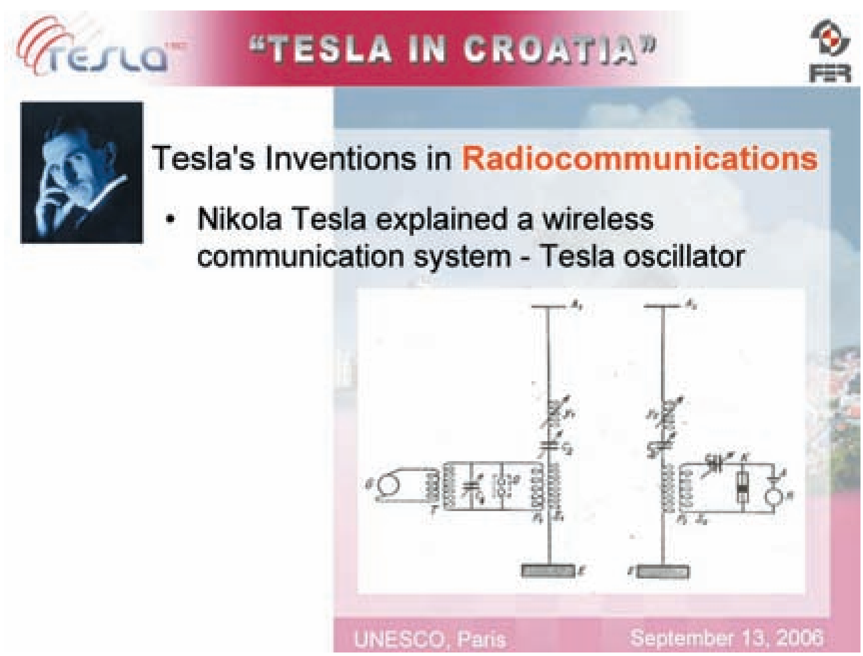
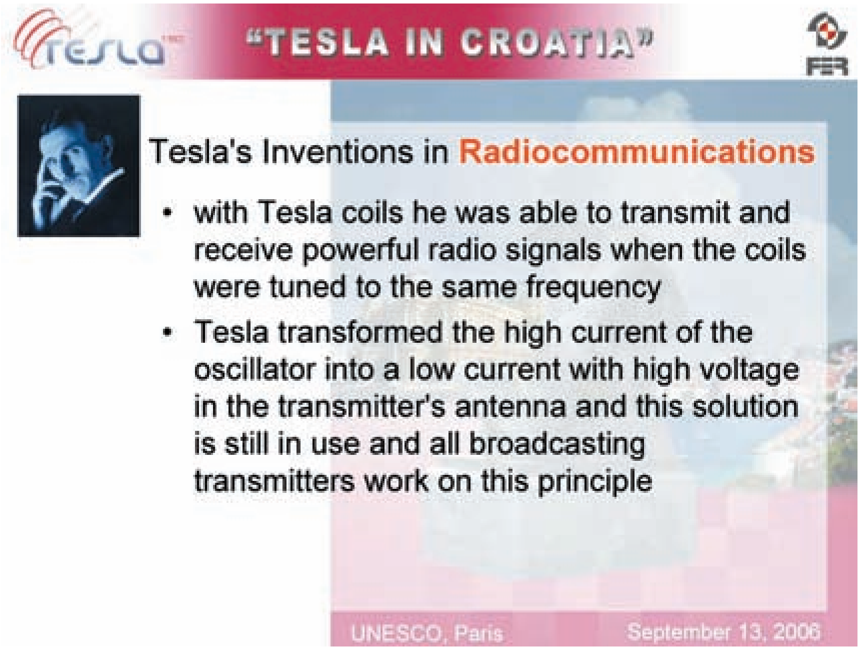

"TESLA IN CROATIA"
Tesla's Inventions in Radiocommunications
• 1891 - patented Tesla coil which could generate extremely high voltages
• experimental Station at Colorado Springs where the first wireless transmission experiments were preformed (1899-1900)
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
Tesla's Inventions in Radiocommunications
• Nikola Tesla explained a wireless communication system - Tesla oscillator
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
Tesla's Inventions in Radiocommunications
• with Tesla coils he was able to transmit and receive powerful radio signals when the coils were tuned to the same frequency
• Tesla transformed the high current of the oscillator into a low current with high voltage in the transmitter's antenna and this solution is still in use and all broadcasting transmitters work on this principle
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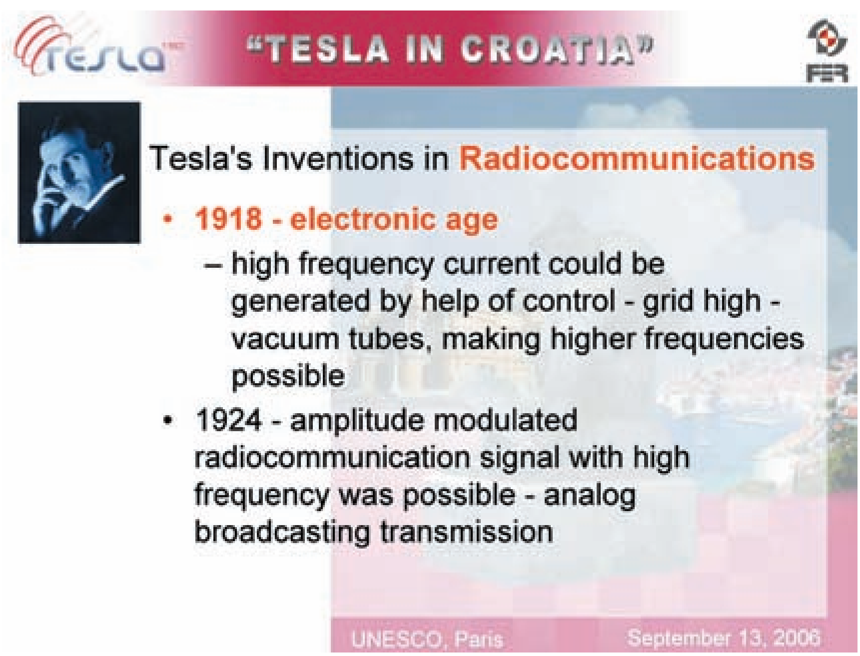
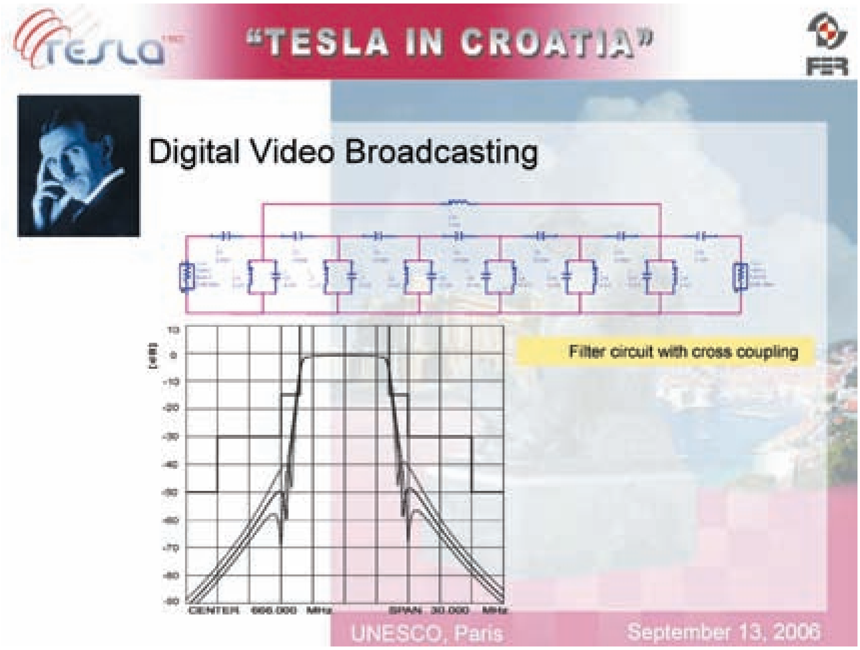
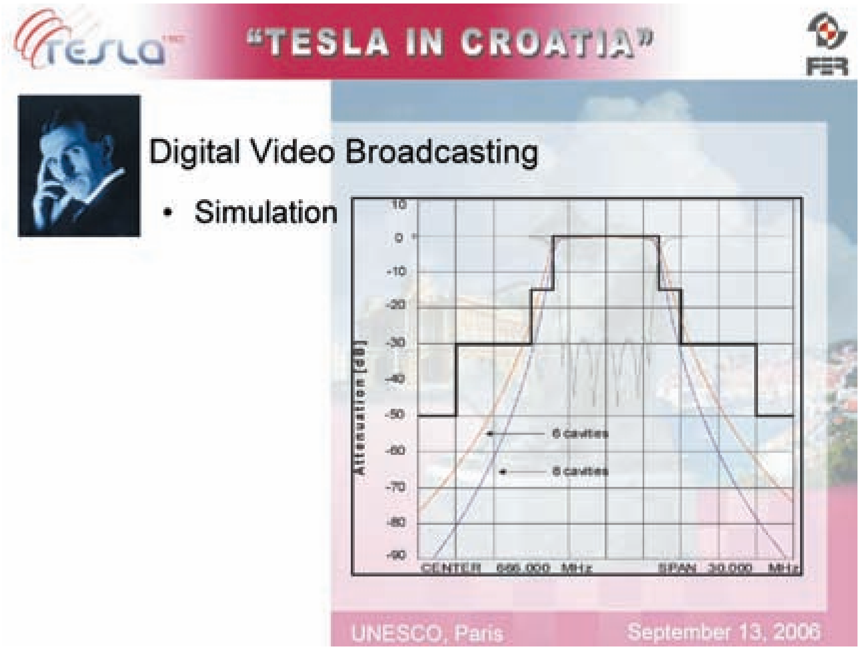

"TESLA IN CROATIA"
FER
Tesla's Inventions in Radiocommunications
• 1918 - electronic age
– high frequency current could be generated by help of control - grid high - vacuum tubes, making higher frequencies possible
• 1924 - amplitude modulated radiocommunication signal with high frequency was possible - analog broadcasting transmission
UNESCO, Paris
September 13, 2006

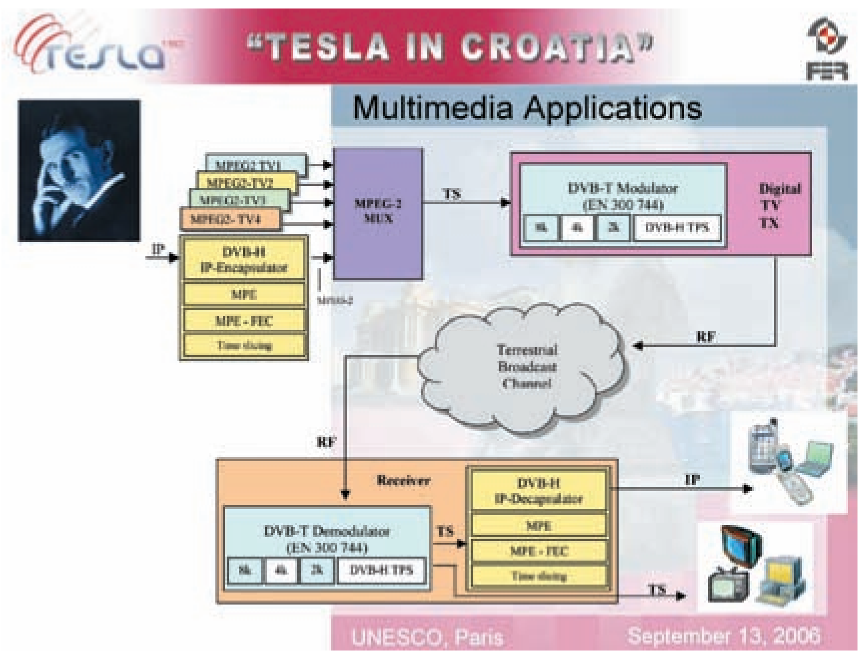

tesla
"TESLA IN CROATIA"
FER
Digital Video Broadcasting
• at the end of 20th century digital signal transmission started, and this new technology enabled development of mobile systems, computer technology, digital television broadcasting and multimedia services transmission
UNESCO, Paris
September 13, 2006


tesla
"TESLA IN CROATIA"
FER
Digital Video Broadcasting
• RRC-0405 Regional Radiocommunication Conference
• Croatia is in revision of Stockholm planning in 1961
• the new digital Plan for Europe, Africa and part of Asia is in the frequency band of analog technology
• new is
– defining the conversion to "all digital future"
– defining out of work analog TV transmitters
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
Digital Video Broadcasting
Filter circuit with cross coupling
CENTER 666.000 MHz
SPAN 30.000 MHz
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
Digital Video Broadcasting
• Simulation
Attenuation [dB]
6 cavities
8 cavities
CENTER 666.000 MHz
SPAN 30.000 MHz
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
Digital Video Broadcasting
• DVB-T Filter 5 kW
The Cable & Satellite International Product of the Year Awards 2005 were presented during IBC 2005 in Amsterdam
WINNER
Cable & Satellite
2005
Product of the Year Awards
Best terrestrial wireless transmission solution
Harris Corporation
DVB-T Liquid Cooled Output Filter 5kW/UHF
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
Multimedia Applications
MPEG2-TV1
MPEG2-TV2
MPEG2-TV4
IP
DVB-H
IP-Encapsulator
MPE
MPE - FEC
MPEG-2
MUX
TS
DVB-T Modulator
(EN 300 744)
8k
4k
2k
DVB-H TPS
Digital
TV
TX
RF
Terrestrial
Broadcast
Channel
RF
Receiver
DVB-H
IP-Decapsulator
MPE
MPE - FEC
IP
DVB-T Demodulator
(EN 300 744)
8k
4k
2k
DVB-H TPS
TS
TS
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
FER
Conclusion
• today DVB-T is the most popular digital terrestrial television system in the world:
– UK, Germany, Sweden, Finland, Spain, Italy The Netherlands, Switzerland, Singapore, Australia, China, Malaysia, Thailand, Vietnam, Ukraine, Croatia, South Africa and others
• all this new technology was Nikola Tesla's dream and this dream is now reality
UNESCO, Paris
September 13, 2006

Stjepan Car, Ph.D.
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KONČAR – Electrical Engineering Institute, Zagreb, Croatia
e-mail: scar@koncar-institut.hr

Nikola Tesla and Končar Group[1]

Abstract

It is almost impossible to imagine the world without polyphase alternating currents and rotating magnetic field discovered by the great visionary, scientist and engineer Nikola Tesla. Tesla's approach to making new discoveries was at the same time both scientific and economic: noticing a problem, birth of the idea and the solution, experimental verification, protection by a patent, presentation of the invention to the most competent, and the promotion of new possibilities to the benefit of all.

Synchronous and induction machines in which electromechanical energy conversion is performed by rotating magnetic fields have today an enormous economic importance, and yet they are only a small part of his creative achievements. Application of new numerical methods, new materials with specific properties, high-temperature superconductivity and information and communication technologies are new challenges for the future development of rotating machines based on Tesla's inventions.

1. Introduction

Nikola Tesla (1856–1943) was one of those visionaries who pioneered electrical engineering at the end of the 19^{th} and the beginning of 20^{th} centuries. He was an inventor of genius whose creative mind was mostly on alternating currents and transmission of electricity, but who also gave a

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[1] Reprinted from *Symposium "Tesla in Croatia": Proceedings*, Croatian Academy of Engineering, ISBN 953-7076-10-5, 2006.

major contribution to the development of turbines, remote control, illumination, lasers, application of high-frequency currents for therapeutic purposes, development of devices for X-rays, which are described in 113 U.S. patents, 17 patents in Great Britain, and 6 patents in Canada, as well as numerous confidential documents which the American Government took over after this death and classified.

On the 150th anniversary of Tesla's birth, it is enough to think back only to several of his inventions related to the rotating magnetic field and polyphase systems for electric power transmission to see the contribution of this great genius to the development of electrical engineering.

2. Tesla's rotating magnetic field

The story of epochal invention of the rotating magnetic field began in 1878, when **Nikola Tesla** studied electrical engineering at the Austria Polytechnic in Graz, and when Professor Jakov Poeschl, Tesla's teacher of theoretical and experimental physics, demonstrated the only just obtained sample of Gramme's direct current generator. When Tesla saw the sparking between the collector and the brushes, he made the bold remark that what should be invented next was a generator without brushes or sparking. The professor answered with a series of arguments and devoted his whole lecture to that problem, and finally concluded: "Mister Tesla will maybe make great things, but it is certain that he will not improve this one. "

Nevertheless, Tesla found the answer while walking with mechanical engineer and his friend Antal Szigety in the Budapest City Park one afternoon in February 1882. Reciting Göthe's Faust, which he knew by heart, he suddenly stopped, and started describing his friend in colourful terms, making drawings in sand, the generation of rotating magnetic field by two alternating currents that flow through two coils shifted in space and a rotating iron rotor. He, in fact, demonstrated the principle of operation of the induction motor, which he patented six years later. Tesla filed the patent application "Electro magnetic motor" on 12 October 1887, and on 1 May 1988 he was granted U.S. Patent 381968. A copy of the drawing from this history-making patent specification and the model of Tesla's two-phase induction motor from the Zagreb Museum of Engineering are shown in figure 1.

In the period from 1888 to 1891 Tesla was granted patents for 36 inventions related to alternating current motors and generators, and 9 related to the electric power transmission and distribution system. Tesla's inventions were very well received, so that he was invited to give a lecture at

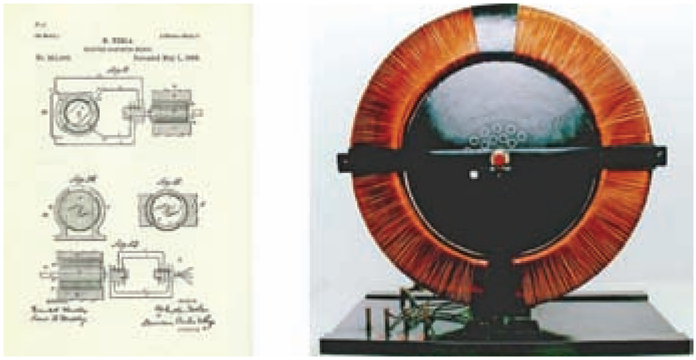

Figure 1. Copy of the printed patent specification for the induction motor of 1 May 1888, which Tesla applied for with the United States Patent Office on 12 October 1887, and the model of Tesla's two-phase induction motor from the Zagreb Museum of Engineering, which Tesla made and demonstrated in Strasbourg on 10 July 1883 – more than four years before the patent application.

the American Institute of Electrical Engineering (AIEE) on 16 May 1888 as an AIEE fellow. The title of the lecture was "A New System of Alternate Current Motors and Transformers", and in it Tesla explained his major inventions and the theory of alternating currents. His public appearance was noticed in Europe as well. German journal Elektrotechnische Zeitschrift (ETZ) of July 1888 published on pages 343 and 344 the article by Du Bois-Reymond titled "Ein neues System von Wechselstrommotoren und Transformotoren von Nikola Tesla", in which he also informed that Tesla gave a lecture at AIEE, and reported in detail about Tesla's explanation and the drawing of the system for electromechanical conversion and transmission of electrical energy (figure 2).

Figure 2. Copy of a part of the article in ETZ, July 1888, pp. 343-344, on Nikola Tesla's new system of alternating motors and transformers presented at the American Institute of Electrical Engineers on 16 May 1888

Figure 3. Demonstration of the effects of rotating magnetic field performed by Nikola Tesla for the first time at the World's Colombian Exhibition in Chicago in 1893

The big promotion of Tesla's polyphase system took place at the World's Colombian Exhibition in Chicago in 1893, where Tesla demonstrated the effects of the rotating magnetic field on a copper egg excited to rotation by the field, figure 4 – a demonstration which attracts the same attention of the public today as it attracted in 1893. On that occasion, 12 two-phase generators and 24 single-phase generators were made and connected by twos in a two-phase alternating system.

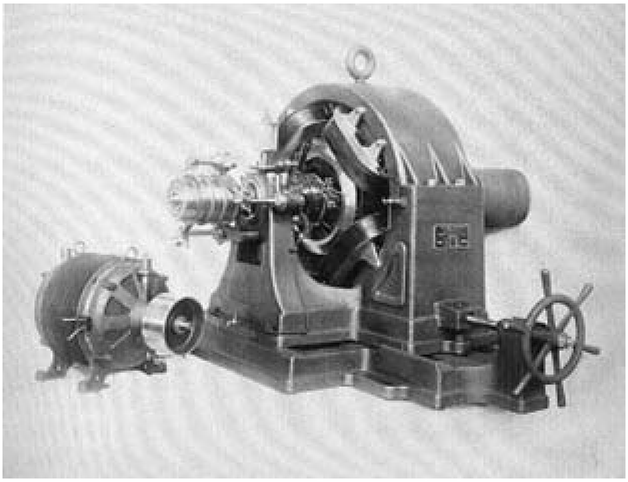

Figure 4. Synchronous generator and induction motor from the time of Nikola Tesla

Even before he was granted patents for polyphase systems, the American industrialist George Westinghouse (1846-1914), who was among the few who understood the importance of induction motors and polyphase systems, showed his interest. Since Tesla was not interested in his own industrial production, only in findings and inventions, in May 1888 Westinghouse Electric and Manufacturing Company bought off all of Tesla's patents in the polyphase current area for USD 1 mil. plus USD 1 for each horse power produced by the machines during the term of the patents (15 years). A photograph of synchronous generator and induction motor produced by Westinghouse under Tesla's patent is given in figure 4.

The greatest economic promotion of Tesla's polyphase systems was the construction of generators for Niagara Falls Hydro-electric Power Plant based on Tesla's patents, figure 5, which was completed in November 1896. At that time the first three-phase 35 kilometres long transmission line from the HPP to Buffalo was also put into service.

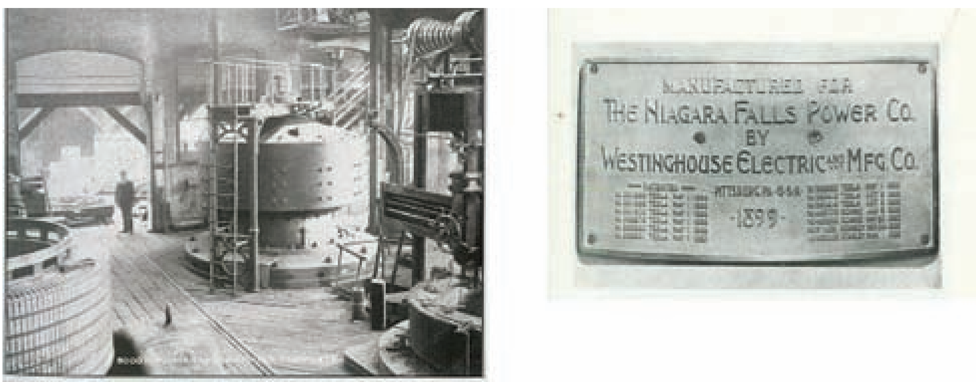

Figure 5. Interior of the turbine hall of Niagara Falls HPP and the name plate of Westinghouse Co. with the list of applied Tesla's patents

On that occasion professor of electrical engineering at the Yale University and former AIEEE chairman Dr. Charles F. Scott concluded his report with these words: "The evolution of electric power from the discovery of Faraday to the initial great installation of the Tesla polyphase system in 1896 is undoubtedly the most tremendous event in all engineering history."

Nikola Tesla had both adversaries and competitors. Tesla made his invention of the induction motor in Budapest in 1882, implemented it in Strasbourg in 1883, filed the patent application on 12 October 1887, and was granted patent on 1 May 1888. When Tesla made this public, two scientists disputed his claims on the invention: the Italian physicist Galileo Ferraris, who claimed the invention of the rotating magnetic field, and in Germany the engineer Michael von Doliwo-Dobrowolski, who was granted German patent 51083 for the three-phase induction motor with short-circuited rotor in Berlin on 8 March 1889.

The patent litigation between Ferraris and Dobrowolski on the one hand and Nikola Tesla on the other hand continued until 1900, when the judge Towsend of the United States Supreme Court in Washington passed his judgement: "Before Tesla's inventions there were no alternating current motors in use … Tesla protected his inventions with patents, and thus developed methods and apparatuses what are nowadays widely known under the name of Tesla's polyphase system, and introduced in the engineering new methods, new means and new terminology …"

This was only a brief overview of Tesla's work related to the rotating magnetic field, electromechanical conversion of energy and polyphase systems, and it has presented only the beginning of Tesla's creative achievements in electrical engineering and energy which were of great importance for the development of electrical industry not only in the world but also in Croatia.

3. Manufacture and usage of alternating electrical machines in Croatia

The first thermal power plant with three steam-engine driven, single-phase 120 kVA, 2000 V alternating generators was constructed in Rijeka in 1892, while the first hydro-electric power plant on the Krka river was put into operation in Šibenik in 1895. Krka HPP had a two-phase 320 kVA, 3000 V, 42 Hz generator.

Although Dr. Milan Amruš, the mayor of Zagreb, invited Tesla as early as in 1892 to consultations about the introduction of electrical lighting and construction of a hydro or thermal power plant with the alternating system (that was on the occasion of Tesla's public appearance at the Old City Hall), the first thermal power plant (called "Munjara") with a Ganz 865 kVA, 5 kV, 50 Hz alternating generator was completed only in 1907.

On 24 January 1921, engineers Felix Rottenbücher, Josip Novaković and others founded in Zagreb a joint stock company **ELEKTRA** d.d. za elektrotehničku i strojarsku industriju (ELEKTRA Inc, electrical and mechanical engineering industries). Not long after its foundation ELEKTRA took over the representation of Siemens Schneckert Werke AG from Vienna. Several months later Siemens entered with their capital, and ELEKTRA was reorganised in Jugoslavensko SIEMENS d.d., with sections for low and high-power currents. That was the beginning of servicing and maintenance of electrical motors in Zagreb – that was also the beginning of the company KONČAR.

Since in 1930 the law was passed in Yugoslavia that allowed domestic products to be 10–15% more expensive, SIEMENS organised in Zagreb the production of induction motors and various electromotor parts.

In 1927 Anton Dolenc became one of SIEMENS employees, and in 1932 he was appointed manager of the plant in Trešnjevka, Zagreb, where Siemens had bought land and built a workshop. He was the spiritus movens of the entire development of the company and inventor of many technical solutions. So, in 1930 the first induction motors with short-circuited rotor and stator winding with lacquered wire instead of cotton-insulated wire were put on the market, what was a novelty on a world scale.


Figure 6. Series of induction motors produced by Jugoslavenski Siemens, and the tour of Eleanor Roosevelt of the production of induction motors in KONČAR in 1953

In 1941 the name of the company was changed in Hrvatsko Siemens d.d., and on 31 December 1946 the Government of FNRJ changed it in "RADE KONČAR". RADE KONČAR became a company of federal importance, whose production programme included the production of **electrical machines, transformers, switching devices and telephones, with 419 workers**, and from 1 January 1991 it operates as the joint stock company **KONČAR – Elektroindustrija d.d.** (KONČAR – Electrical Industry, Inc.) in mixed ownership, with a number of subsidiaries specialised in individual groups of products for the power sector, electric traction and household appliances.

The first induction motor whose diameter of the active part exceeded one meter was delivered in 1948, and in the same year the first Končar's 24 MVA synchronous generator was put into operation in the hydro-electric power plant HPP Mariborski otok (figure 7).

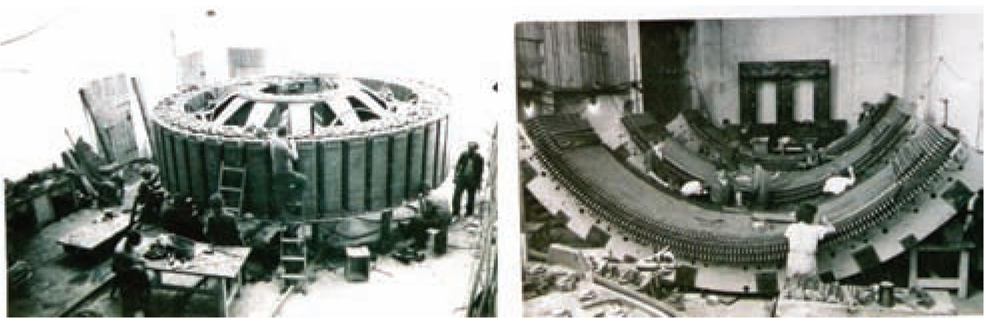

Figure 7. Manufacture of stator and rotor of 24 MVA, 10 kV, 125 r.p.m. synchronous generator for Mariborski otok HPP (1946)

That traced the way for an independent development of alternating electrical machines in Croatia. The development could not be possible without qualified experts and engineers. In 1848 it was proposed to found the Zagreb Technical University, but it was done so. In 1926 the University became Faculty of Engineering. In 1956 the Faculty of Engineering became the Faculty of Electrical Engineering, and from 1995 it is called the Faculty of Electrical Engineering and Computing. The Faculty was the place where a number of engineers and eminent experts were trained, and many of them worked on the development, design and construction of electrical machines, and at the same time they were professors at the Faculty. Besides the legendary professor Anton Dolenc, a pioneer in the design and technical solutions of induction motors and synchronous generators, who was appointed part-time lecturer at the Zagreb Faculty of Engineering in 1930, there were also other engineers and university professors who made major contributions to the development of alternating machines, of which I shall mention only a few:

- Prof. Dr. Tomo Bosanac, who designed and managed the construction of 2x120 MVA hydrogenerators (the largest at the time) for Zakučac HPP, which was put into operation in 1962.

- Prof. Dr. Zijad Haznadar, world-renowned theoretician of electromagnetic fields, who was the first to introduce numerical methods for calculation of fields in machines, and studied the expansion and effects of electromagnetic waves
- Prof. Dr. Božidar Frančić, who patented the self-excited compound synchronous generator, and introduced the theory of dynamic states of alternating machines in the post-graduate studies
- Prof. Dr. Berislav Jurković, who set the methods for calculation of induction machines, and gave a number of new technical solutions for multi-speed motors for heavy duties
- Prof. Dr. Sc. Zvonko Sirotić, who designed the largest hydrogenerators for Đerdap HPP, and set the principles for building synchronous generators of limit powers
- Prof. Dr. Radenko Wolf, who set the method for calculation of small single-phase motors with an auxiliary phase, and gave an essential contribution to the physical image and theory of various kinds of electrical machines, in particular of small ones.

It is worth pointing out here to the name of Prof. Dr. Vladimir Muljević, who defended in 1942 the doctoral thesis "The emergence of higher harmonics in squirrel-cage rotors with numerous slots in Tesla motor" as the first doctoral thesis in Croatia dealing with alternating electrical machines.


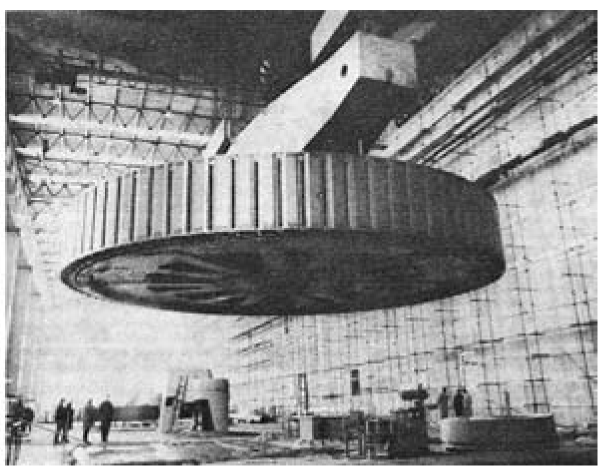

Figure 8. Interior of the turbine hall in Đerdap HPP under construction. KONČAR delivered three 190 MVA hydrogenerators, 1240 tons each, which were put into service in 1972.

Fig. 9 – Various testing points at the Laboratory for Rotating Machines in KONČAR – Electrical Engineering Institute, which has been put into operation in 1971.

In order to speed up the development and become competitive on the world market, KONČAR established within the Electrotechnical Institute, which was founded in 1961, the **Laboratory for Rotating Machines**, which was put into operation in 1971 with all the necessary facilities for research, testing and development of electrical machines and electromotor drives (the testing of electrical materials, electromechanical characteristics, noise and vibrations, temperature rises and cooling, climatic tests, tests of mechanical protection, tests with sinusoidal and non-sinusoidal voltages at various frequencies, and simulations of states in operation), figure 9.

For their scientific and research work and exceptional contribution to the development of KONČAR, as many as 14 engineers and scientists from the 33 winners of the Nikola Tesla Award so far have been working on rotating machines.

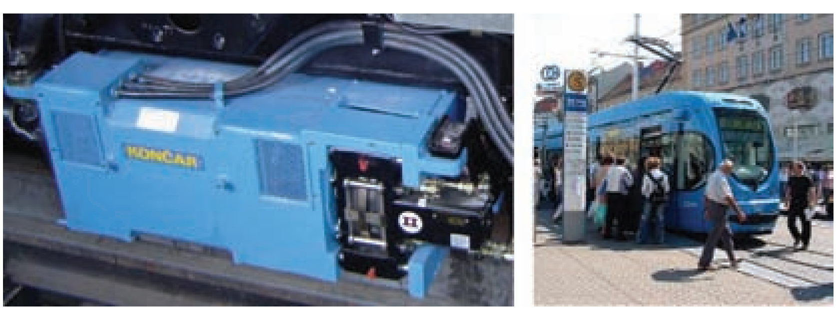

Figure 10. Induction motor for frequency-controlled electric motor drive of the low-floor tramway, and its first drive in Zagreb in 2005

The greatest success of the domestic electrical industry today is our own development and production of the low-floor tramway for the City of Zagreb, with induction motors and frequency control of the speed of rotation of the rotating magnetic field, figure 10. The first tramway was delivered in autumn 2005, and today there are already 34 trams driving in streets of Zagreb (of total 70 tramways to be delivered under the first contract).

4. Economic importance of the rotating magnetic field and rotating machines

The world market of electrical machines is worth today more than USD 4.7 b., and it is anticipated that its annual increase would be about 8%, in particular in the area of electrical propulsion for ships, figure 11. Končar alone produces rotating machines whose value exceeds € 35 mil. p.a. Almost 70% of them is exported.

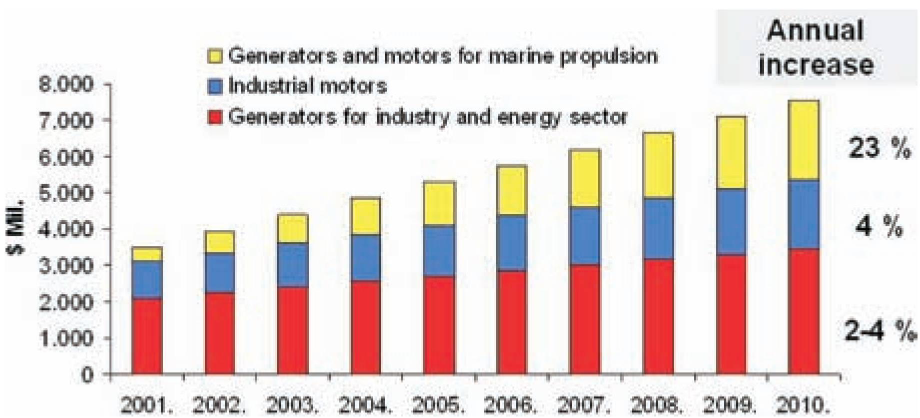

Figure 11. Estimation of the market of rotating machines (Source: AMSC, Arthur D. Little)

Electronic control by power converters and IT systems are more and more used in modern electric motor drives and plants with synchronous and induction machines, giving them quite new features.

Further development of alternating electrical machines, aided by new numerical methods for calculation and modelling and new materials with specific properties such as superconducting materials and rare-earth permanent magnets with new and improved features, goes in the direction of an increasing constructional and control integration of these machines in plants and processes, with the resulting permanent increase in the efficiency of electromechanical conversion of energy and reductions of machine size.

Ever since Nikola Tesla discovered the rotating magnetic field and electromechanical conversion of energy, alternating electrical machines have been not only of great technical and technological, but also of economical importance. Many jobs and the creation of added value are connected with them, and it is likely that that they will likely remain so for a long, long time.

References

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2. V. Popović, R. Horvat, N. Nikolić: Nikola Tesla – lectures, patents, articles, Nikola Tesla Museum, Beograd, 1956.
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4. V. Popović: Tribute to Nikola Tesla – presented in articles, letters documents, Nikola Tesla Museum, Beograd, 1961.
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11. V. Muljević: Nikola Tesla – slavni inventor, Hrvatska zajednica tehničke kulture, Zagreb, 2000.
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13. Z. Haznadar: Elektrotehnika: Razvoj i perspektive u svijetu i Hrvatskoj, Energija (2001)2, 67-122.
14. J. Moser: Pregled razvoja elektroprivredne djelatnosti u Hrvatskoj 1875.-2002., Kigen, Zagreb, 2003.
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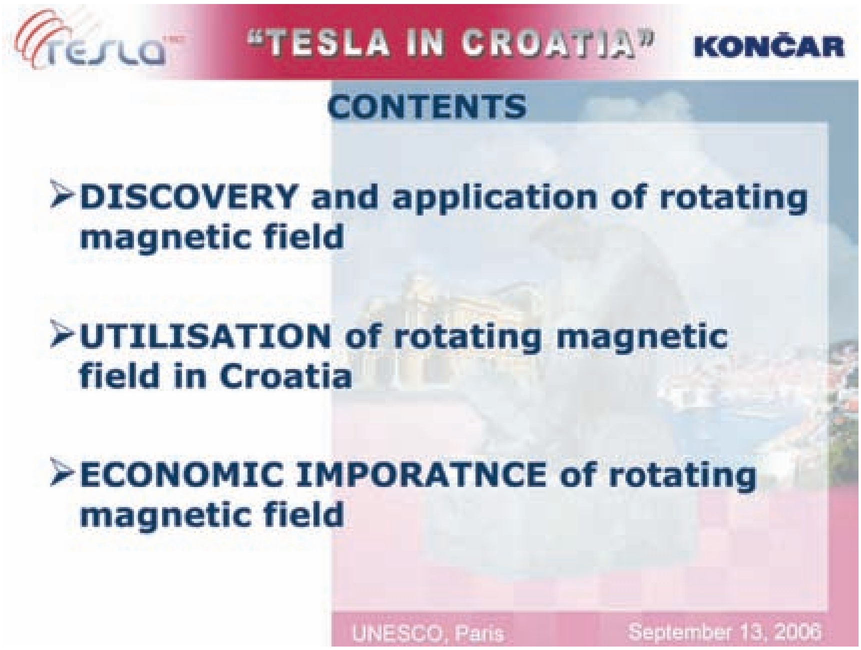
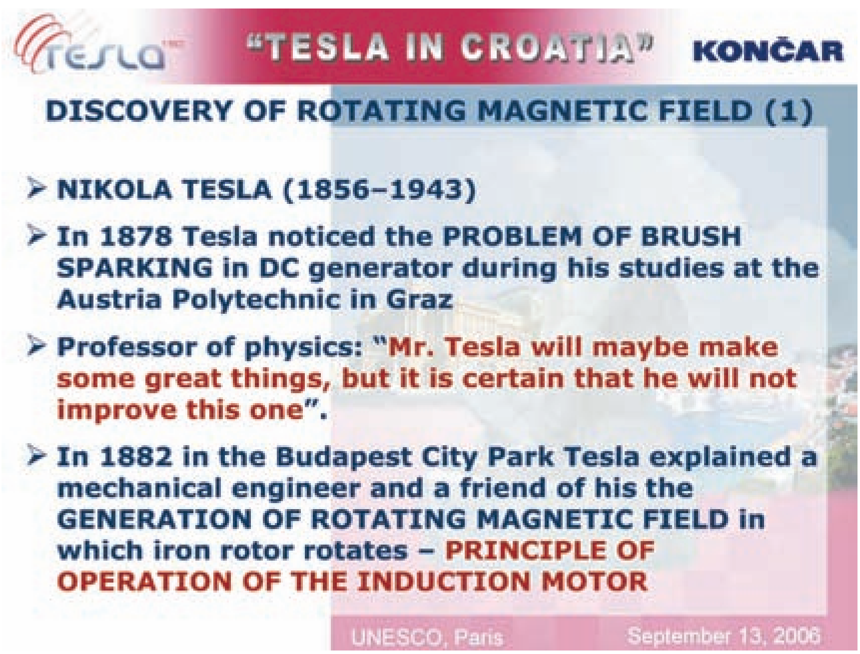
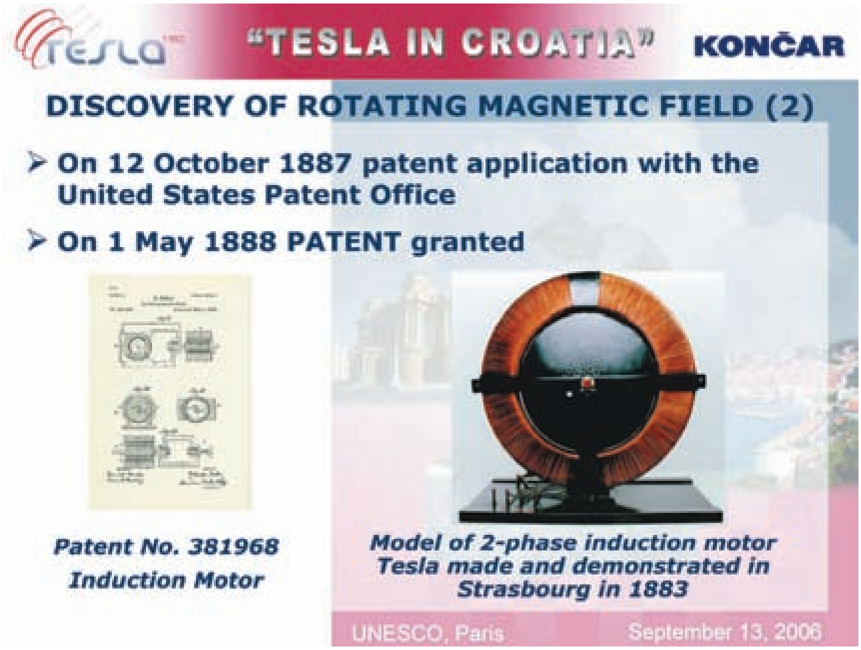
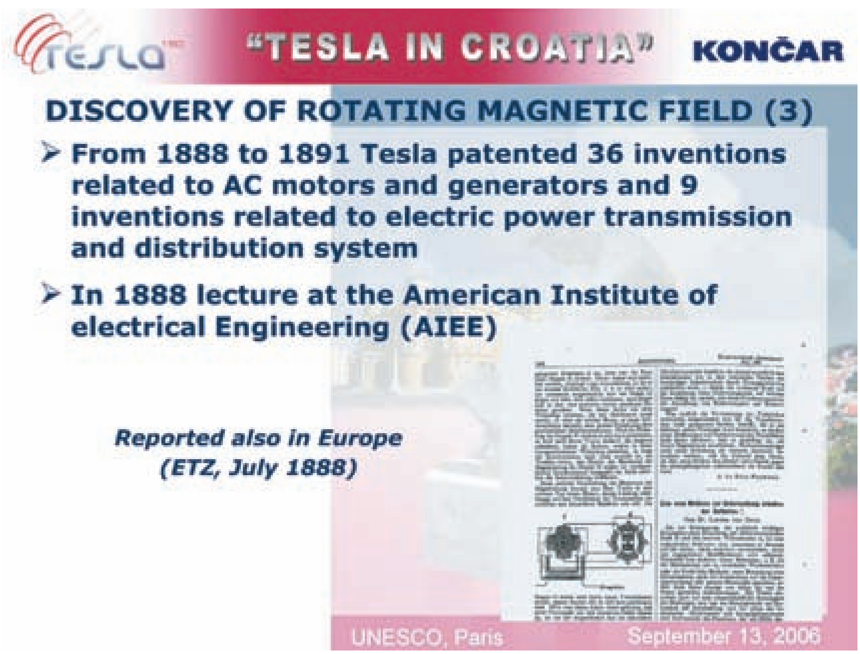
Appendix


"TESLA IN CROATIA"
KONČAR
CONTENTS
➢DISCOVERY and application of rotating magnetic field
➢UTILISATION of rotating magnetic field in Croatia
➢ECONOMIC IMPORATNCE of rotating magnetic field
UNESCO, Paris
September 13, 2006

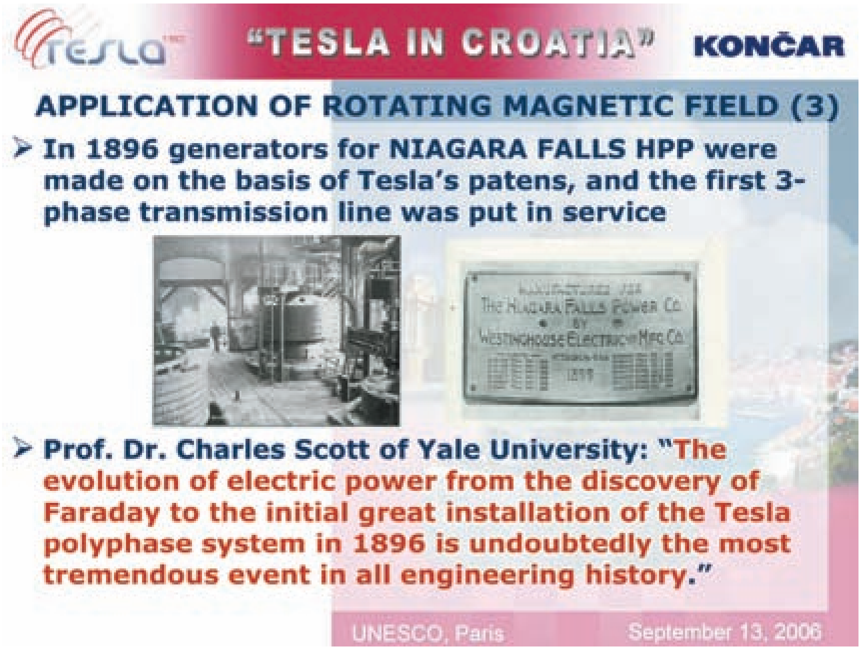

"TESLA IN CROATIA"
KONČAR
DISCOVERY OF ROTATING MAGNETIC FIELD (1)
➢ NIKOLA TESLA (1856–1943)
➢ In 1878 Tesla noticed the PROBLEM OF BRUSH SPARKING in DC generator during his studies at the Austria Polytechnic in Graz
➢ Professor of physics: "Mr. Tesla will maybe make some great things, but it is certain that he will not improve this one".
➢ In 1882 in the Budapest City Park Tesla explained a mechanical engineer and a friend of his the GENERATION OF ROTATING MAGNETIC FIELD in which iron rotor rotates – PRINCIPLE OF OPERATION OF THE INDUCTION MOTOR
UNESCO, Paris
September 13, 2006

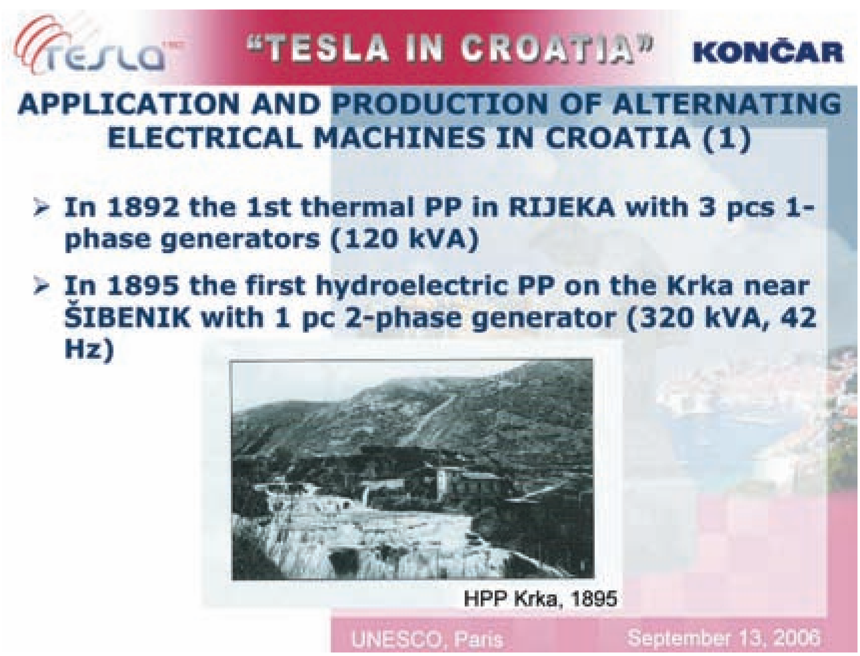

"TESLA IN CROATIA"
KONČAR
DISCOVERY OF ROTATING MAGNETIC FIELD (2)
➢ On 12 October 1887 patent application with the United States Patent Office
➢ On 1 May 1888 PATENT granted
Patent No. 381968
Induction Motor
Model of 2-phase induction motor Tesla made and demonstrated in Strasbourg in 1883
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
KONČAR
DISCOVERY OF ROTATING MAGNETIC FIELD (3)
➢ From 1888 to 1891 Tesla patented 36 inventions related to AC motors and generators and 9 inventions related to electric power transmission and distribution system
➢ In 1888 lecture at the American Institute of electrical Engineering (AIEE)
Reported also in Europe
(ETZ, July 1888)
UNESCO, Paris
September 13, 2006

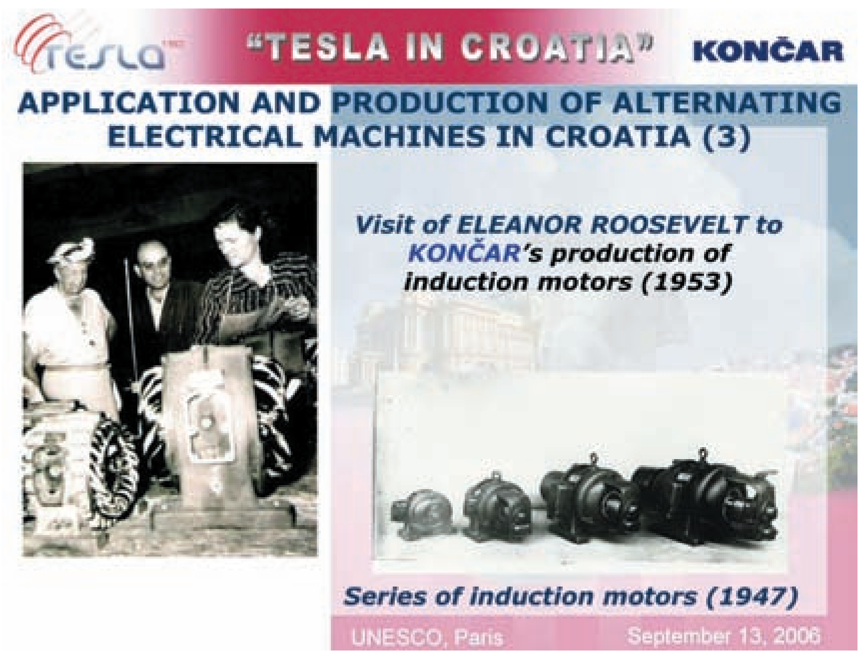

"TESLA IN CROATIA"
KONČAR
APPLICATION OF ROTATING MAGNETIC FIELD (1)
➢ In 1893 PROMOTION of Tesla's polyphase system at the World's Colombian Exhibition in Chicago (12 pcs 2-phase 1000 HP generators and 24 pcs 1-phase 500 HP ones connected in a system)
Replica of a model for demonstration of effects of rotating magnetic field
KONČAR
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
KONČAR
APPLICATION OF ROTATING MAGNETIC FIELD (2)
➢ In 1888 Westinghouse Electric and Manufacturing Company BOUGHT OFF for USD 1 mil. + USD 1 per HP all of Tesla's patents in the polyphase current area
UNESCO, Paris
September 13, 2006

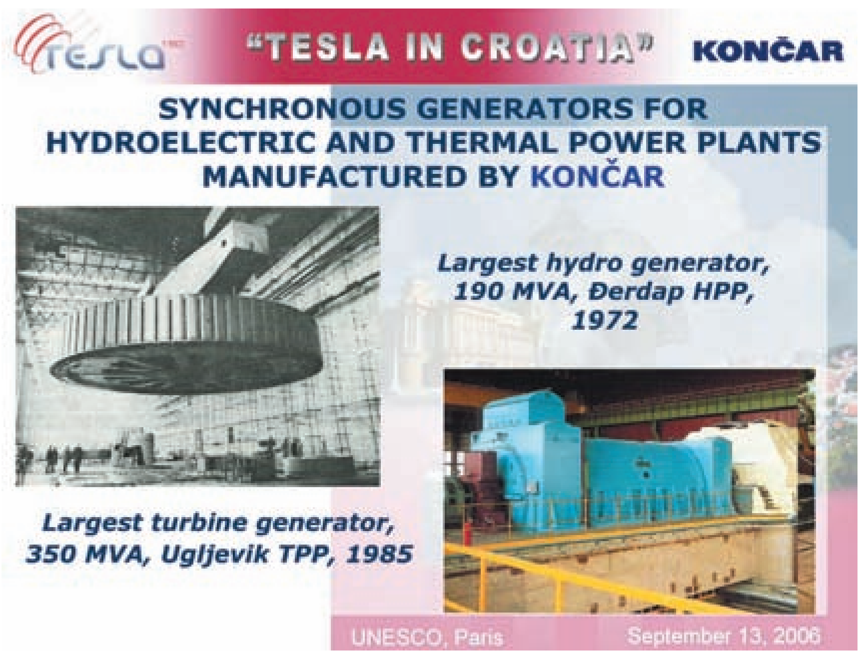

TESLA
"TESLA IN CROATIA"
KONČAR
APPLICATION OF ROTATING MAGNETIC FIELD (3)
In 1896 generators for NIAGARA FALLS HPP were made on the basis of Tesla's patens, and the first 3-phase transmission line was put in service
THE NIAGARA FALLS POWER CO.
BY
WESTINGHOUSE ELECTRIC & MFG CO.
Prof. Dr. Charles Scott of Yale University: "The evolution of electric power from the discovery of Faraday to the initial great installation of the Tesla polyphase system in 1896 is undoubtedly the most tremendous event in all engineering history."
UNESCO, Paris
September 13, 2006


TESLA
"TESLA IN CROATIA"
KONČAR
APPLICATION AND PRODUCTION OF ALTERNATING ELECTRICAL MACHINES IN CROATIA (1)
In 1892 the 1st thermal PP in RIJEKA with 3 pcs 1-phase generators (120 kVA)
In 1895 the first hydroelectric PP on the Krka near ŠIBENIK with 1 pc 2-phase generator (320 kVA, 42 Hz)
HPP Krka, 1895
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
KONČAR
APPLICATION AND PRODUCTION OF ALTERNATING ELECTRICAL MACHINES IN CROATIA (2)
In 1921 foundation of the company ELEKTRA, Inc. for electrical & mechanical engineering industries
Six months later: Jugoslavensko SIEMENS Inc., in 1941 Hrvatsko SIEMENS
In 1946 the company became social property and operated under the name RADE KONČAR
Since 1991 KONČAR - ELEKTROINDUSTRIJA d.d. with subsidiaries specialised in electrical power sector, electric traction and household appliances
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
KONČAR
APPLICATION AND PRODUCTION OF ALTERNATING ELECTRICAL MACHINES IN CROATIA (3)
Visit of ELEANOR ROOSEVELT to KONČAR's production of induction motors (1953)
Series of induction motors (1947)
UNESCO, Paris
September 13, 2006

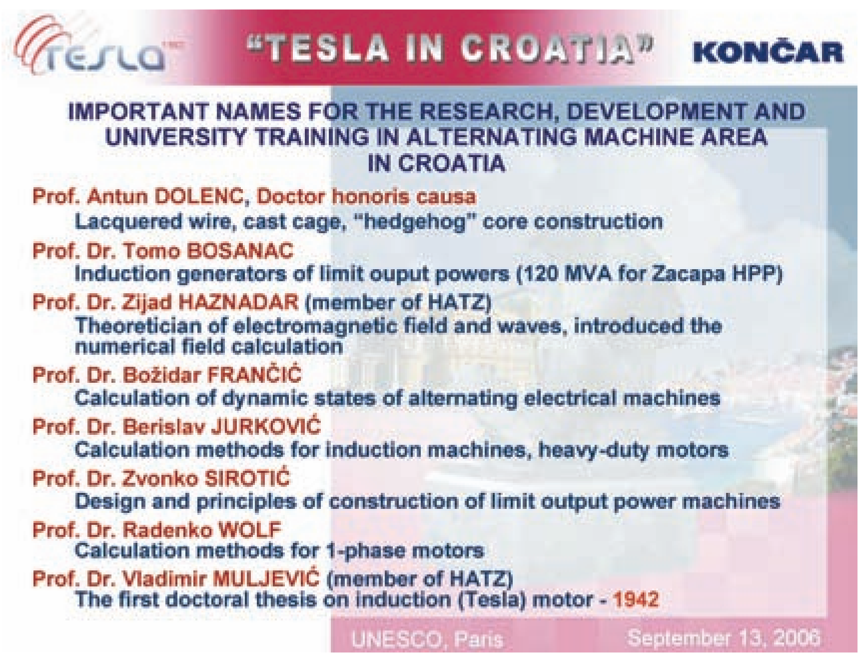

"TESLA IN CROATIA"
KONČAR
MANUFACTURE OF STATOR AND ROTOR OF 24 MVA SYNCHRONOUS GENERATOR FOR MARIBORSKI OTOK HPP IN KONČAR IN 1946
UNESCO, Paris
September 13, 2006

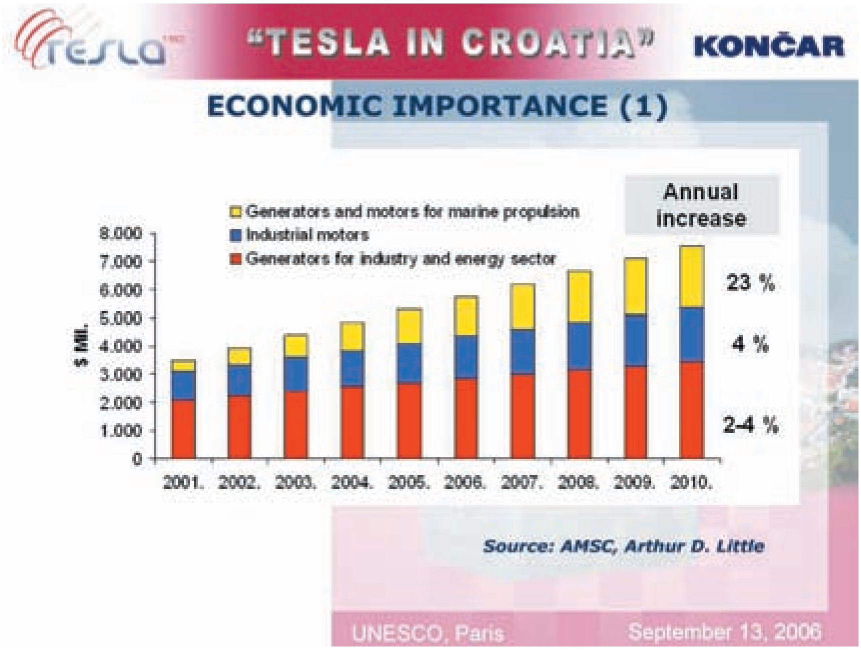

"TESLA IN CROATIA"
KONČAR
SYNCHRONOUS GENERATORS FOR HYDROELECTRIC AND THERMAL POWER PLANTS MANUFACTURED BY KONČAR
Largest hydro generator, 190 MVA, Đerdap HPP, 1972
Largest turbine generator, 350 MVA, Ugljevik TPP, 1985
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
KONČAR
LABORATORY FOR ROTATING MACHINES
AT KONČAR INSTITUTE IN OPERATION SINCE 1971
As many as 14 engineers and scientists from the area of rotating machines have been awarded the NIKOLA TESLA STATE AWARD for their scientific and research work and exceptional contribution to the development of KONČAR
UNESCO, Paris
September 13, 2006

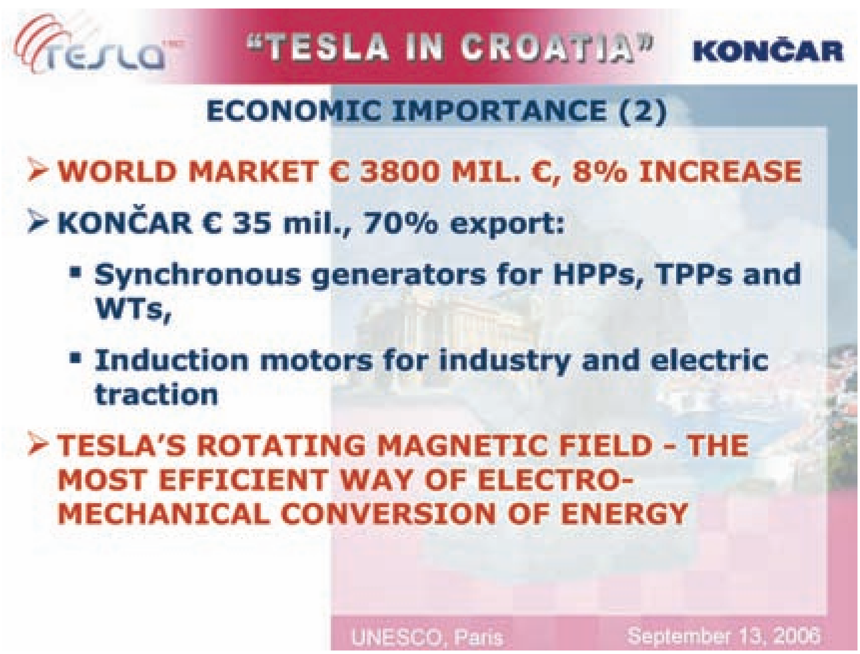

"TESLA IN CROATIA"
KONČAR
INDUCTION MOTOR FOR FREQUENCY-CONTROLLED
ELECTRIC MOTOR DRIVE OF LOW-FLOOR TRAMWAY
PRODUCED BY KONČAR
Commencement of production in 2005
Low-floor tramway for the city of ZAGREB (70 pcs)
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
KONČAR
COUNTRIES IN WHICH KONČAR'S ALTERNATING MACHINES ARE INSTALLED
UNESCO, Paris
September 13, 2006


"TESLA IN CROATIA"
KONČAR
IMPORTANT NAMES FOR THE RESEARCH, DEVELOPMENT AND UNIVERSITY TRAINING IN ALTERNATING MACHINE AREA IN CROATIA
Prof. Antun DOLENC, Doctor honoris causa
Lacquered wire, cast cage, "hedgehog" core construction
Prof. Dr. Tomo BOSANAC
Induction generators of limit ouput powers (120 MVA for Zacapa HPP)
Prof. Dr. Zijad HAZNADAR (member of HATZ)
Theoretician of electromagnetic field and waves, introduced the numerical field calculation
Prof. Dr. Božidar FRANČIĆ
Calculation of dynamic states of alternating electrical machines
Prof. Dr. Berislav JURKOVIĆ
Calculation methods for induction machines, heavy-duty motors
Prof. Dr. Zvonko SIROTIĆ
Design and principles of construction of limit output power machines
Prof. Dr. Radenko WOLF
Calculation methods for 1-phase motors
Prof. Dr. Vladimir MULJEVIĆ (member of HATZ)
The first doctoral thesis on induction (Tesla) motor - 1942
UNESCO, Paris
September 13, 2006



"TESLA IN CROATIA"
KONČAR
ECONOMIC IMPORTANCE (1)
Annual increase
Generators and motors for marine propulsion
Industrial motors
Generators for industry and energy sector
$ Mil.
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0
2001. 2002. 2003. 2004. 2005. 2006. 2007. 2008. 2009. 2010.
23 %
4 %
2-4 %
Source: AMSC, Arthur D. Little
UNESCO, Paris
September 13, 2006



"TESLA IN CROATIA"
KONČAR
ECONOMIC IMPORTANCE (2)
WORLD MARKET € 3800 MIL. €, 8% INCREASE
KONČAR € 35 mil., 70% export:
Synchronous generators for HPPs, TPPs and WTs,
Induction motors for industry and electric traction
TESLA'S ROTATING MAGNETIC FIELD - THE MOST EFFICIENT WAY OF ELECTRO-MECHANICAL CONVERSION OF ENERGY
UNESCO, Paris
September 13, 2006

“With Tesla to the Progress of Croatia”

November 24, 2006, Zagreb, Croatia

Folk ensemble presented our tradition

Ambasadors attend lectures

Prof. **Vedran Mornar**, Ph.D.
Faculty of Electrical Engineering and Computing,
University of Zagreb, Zagreb, Croatia
e-mail: vedran.mornar@fer.hr

Bologna Process and the Education for the 21st Century

Faculty of Electrical Engineering and Computing, University of Zagreb (Fakultet elektrotehnike i računarstva, FER), is traditionally producing high quality engineers. According to the German higher education model, the integral study program lasting for 9 semesters has been resulting in the academic title *dipl.ing*. Although the graduates are highly employable and relevant to the labor market, some shortcomings of that model were identified. It was too much teaching oriented, with almost 30 contact hours per week. The class attendance was irregular, with apparent campaign behavior of the students who studied mostly before and for the exams, which in turn could be repeated eight times for each course.

On the other hand, the Bologna declaration, convened in Bologna on 19th of June 1999 as a joint declaration of the European ministers of Education, states several principle goals of the European system of higher education:

- Adoption of a system of easily readable and comparable degrees, essentially based on two main cycles, undergraduate (bachelor) and graduate (master),
- Establishment of ECTS points (European Credit Transfer System) as a means of promoting the student mobility,
- Promotion of mobility for students, teachers, researchers and administrative staff,

- Promotion of quality assurance,
- Promotion of European dimensions in higher education.

To conform to the Bologna process, Croatian higher education system had to be considerably redesigned in the academic year 2005/2006, which was targeted by the government as a milestone for implementation of the reform of all study programs. FER grasped this opportunity not only to formally adapt to the Bologna principle, but also to make substantial changes in the manner how the study is conducted, and to achieve some additional goals: keep in pace with current advances in science and technology, adjust the curriculum to the needs of the modern labor market, switch from teaching to learning, give importance to competences and to be internationally recognized.

Competences of bachelors and masters had to be clearly distinguished and the content of the courses had to be redesigned accordingly. Instead of the study which started with a very difficult and eliminatory first year, and which was becoming easier as it was approaching the final year, we had to identify the knowledge which would enable the bachelor to analyze and solve engineering problems of moderate complexity, participate in a team, take part in the design of systems and processes in the fields of electrical engineering, information and communication technology and computing, using fundamental knowledge of mathematics, physics, electrical engineering and computing, with contemporary computer tools. In contrast, the master's domain are the complex problems, masters should lead teams and autonomously design systems and processes. Clearly, the complexity of the curriculum content had to be moved to the second degree study.

The education paradigm had to be shifted from teaching to learning. This was achieved by reducing the number of contact hours to 20 per week at the bachelor and to 16 at the master level, and by introducing more individual work and homework. The students are now graded solely upon the results of the continuous assessment. All student activities contribute with a certain number of points. Maximal number of points earned on a course is 100. In general, regular class attendance is expected from all students. However, the regular attendance makes a contribution of 5-10 points. The contributions of other activities are: homework: 10-20 points; laboratories: 5-15 points; mid-term exams: 20-50 points; final exam: 20-40 points. At the beginning of each course, the lecturer must inform students of the method of evaluation to be used in the course and about exact number of points for different assessed components. This information must be available on the faculty web site. The final and mid-term exams may be written, or oral and written. The part of exam may be a presentation of practical work. Minimal number of points necessary to pass the exams is recommended to be 50. Little exceptions are allowed depending on the specific course structure. A student will fail an exam if the total number of collected points is less then required minimum. In that case the result of the first final exam is deleted, and the student can repeat the final exam only once. Students who fail a course must repeat that course in the following academic year.

All students achieve the final grades after the second final exam is finished. The final grade depends on the position on the rank-list of total points as follows:

grade 5 (A): top 15 % of students
grade 4 (B): next 35 % of students
grade 3 (C): next 35 % of students
grade 2 (D): next 15 % of students

The lectures and exams in a semester are scheduled as follows:

Weeks 1-5.	Lectures
Week 6.	Laboratory and preparation for first mid-term exams
Week 7.	First mid-term exams
Weeks 8-11.	Lectures
Week 12.	Laboratory and preparation for second mid-term exams
Week 13.	Second mid-term exams
Weeks 14–17.	Lectures
Week 18.	Laboratory and preparation for final exams
Week 19.	Final exams
Week 20.	Repeated final exams

After the summer semester, students work on their personal skills in the duration of 4 weeks. These skills are acquired through various courses, summer schools or practical work, at the faculty or in the industry. Thus, the total duration of an academic year is 44 weeks, and the students are expected to gather 60 ECTS points during an academic year.

All study programs in Croatia have to be accredited by the National council for higher education. FER obtained that accreditation, but we wanted to now if we are good enough in the international environment. So we decided to seek for an international accreditation. ASIIN (*Akkreditierungs-agentur für Studiengänge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften und der Mathematik*), the only German accreditation agency for engineering and science, was a logical choice, especially because of their internal structure, which contains technical committees for Electrical engineering / Information technology and for Informatics, which fits perfectly with the domain of FER. The study programs had to fit ASIIN's requirements on the curriculum structure, which is illustrated with the following example, denoting the requirements for bachelor programs in Electrical engineering and information technology.

Content	Percent	ECTS
Fundamentals of mathematics and natural sciences	20	36
Fundamentals of electrical and information engineering	25	45
Core subjects/subject-specific advanced focal subjects	30	54
Cross-subject contents (non-technical subjects)	10	18
Discretionary contents	8	15
Bachelor’s Thesis	7	12

The curriculum of FER, the manner how the study is conducted, together with the spatial and human resources, satisfied ASIIN criteria so FER became first and only internationally accredited faculty in the Republic of Croatia.

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HEP, Zagreb, Croatia
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European Electric Interconnection

Tesla's inventions and works – science fiction? YES, because Tesla and his works were not understood by most of his contemporaries. Fortunately, there were some who trusted Tesla despite his at times difficult-to-understand experimentally illustrated ideas and inventions. Even with today's knowledge, it is difficult to escape the feeling that it is science fiction since up to the present day the human mind has not materialized some of Tesla's inventions. Science fiction, NO, because the future for which Tesla, as he would put it, worked, has irrefutably proved that his ideas and inventions were firmly grounded in the reality. Tesla was and has remained a mind outside his time and, by some of his ideas that have not been realized, outside today's space and time. Without Tesla, his ideas, inventions and works, there would not be many of the comforts of living on Earth, within and in the space surrounding it.

Thousands and thousands of electricity specialists all over the world are engaged in the electricity transmission. The fundamentals of the modern electricity transmission were established by Tesla toward the end of the nineteenth century by his inventions of polyphase alternating electric motor and electricity transmission. These inventions Tesla patented in 1888 when he was barely 32 years old. At that time it was difficult for Tesla to defend his ideas about polyphase alternating currents against the powerful Edison as the main proponent of the direct current. Tesla won, but Edison was the one who made use of his works and patents. A simple drawing from one of these of Tesla' patents (No. 390,721 dated

October 9, 1888), depicts all the basic elements of the modern electricity system: generator, transformer, motor and end use.

It was from these ideas that the modern electric power system has been developed consisting of power plants, transmission lines, transmission substations and a whole spectrum of electricity users such as large industrial plants connected directly to the transmission network and distribution systems supplying electricity to end customers in public institutions, companies and homes. Tesla's ideas of making electricity and information available at any place on Earth, 150 years after his birth, are getting closer to being fully realized.

Can we today imagine living without electricity? Of course, it would be possible, but the world would be a very different place. We have come far from Tesla's childhood days when he in his hometown of Smiljan read and studied by a lamp and a candle. That life is unimaginable without electricity is reflected in the concrete data on electricity consumption. In 2004, consumption in North America was 4338 TWh, in Central and South America 734 TWh, Europe 3064 TWh, in the countries of the former Soviet Union 1148 TWh, in the Middle East 456 TWh, in Africa 422 TWh, Asia and Oceania 3921 TWh and Australia 196 TWh. The total world-wide consumption amounted to 14279 TWh. For comparison, the consumption in Croatia in 2004 was 16.5 TWh.

Such an impressive electricity consumption is made possible by modern electric power systems meshed in large and complex interconnected systems. The basic requirement for the functioning of an electricity system is to maintain balance at all times between production and consumption while ensuring quality of the two basic parameters of electricity, voltage and frequency. It has been proved that large interconnected power systems provide such benefits in terms of supply security and quality of electricity that their creation and expansion is unavoidable despite technical and organizational difficulties that must be overcome. Such a development can be illustrated by a historical review of the beginnings and development of European electric interconnected systems – UCTE, NORDEL, UKTSOA, ATSOI,…. The most significant among them is the UCTE (The Union for Coordination of Transmission of Electricity) established in 1999 by transforming UCPTE (Union pour la Coordination de la Production et du Transport de l'Electricite) on the basis of the well-known EU Directive 96/2. The UCTE encompasses transmission network in 23 countries and is one of the largest interconnected systems in synchronous operation in the world. With 600 GW of installed capacity in power plants and an annual production of 2500 TWh, the UCTE supplies electricity to 450 million people.

The war in the area of the former Yugoslavia split, in 1991, the then UCPTE interconnected system in two zones, each of which operated synchronously. The second synchronous zone comprised the electric power systems of South East Europe (eastern part of Bosnia and Herzegovina, Serbia and Montenegro, Macedonia, Greece, Albania, and later Romania and Bulgaria), and the first zone comprised all other countries, including Croatia and the remaining part of Bosnia and Herzegovina.

Following the reconstruction of the transmission network in Croatia and in Bosnia and Herzegovina and the construction of the strategically important 400 kV connection between Croatia and Hungary, the conditions were created for the reconnection of the two synchronous zones. An executive team was set up within the UCTE and careful preparations began for this complex task. As part of these preparations, on September 25, 2004, alignment of phase sequence was carried out on the interconnections between the Croatian system and neighboring countries of the first synchronous zone (Hungary and Slovenia).

The reconnection itself took place on October 10, 2004, beginning at 09:34 and unfolded as follows:

- switching on of the 400 kV line Sandorfalva (Hungary) – Arad (Romania), at the same time the synchronization of the two synchronous zones
- switching on of the 400 kV line Subotica (Serbia) – Sandorfalva (Hungary)
- switching on of the 400 kV line Trebinje (Bosnia and Herzegovina) – Podgorica (Montenegro)
- switching on of the 400 kV line Mukachevo (southwest Ukraine) – Rosiori (Romania)
- switching on of the 400 kV line Ernestinovo (Croatia) – Mladost (Serbia).

All the activities were coordinated from the National Dispatch Center in Zagreb. The dynamic behavior of the Croatian system was recorded and, using UCTE WAMS system, the frequency and differences in voltage angles in two characteristic nodes of the first and second synchronous zones were constantly monitored. Thanks to the good preparation and organization, the reconnection was successfully completed at 10:58, barely an hour and a half from the start of reconnection.

The dynamic behavior of the system during reconnection indicated a potential problem with inter-area oscillations, which was confirmed by later dynamics records. This problem should be approached with due care and is currently being addressed by a specialist working group of the UCTE.

In 2004, the UCTE interconnected system had the production of 2448 TWh, consumption of 2393 TWh, installed capacity of 595 GW and peak load of 370 GWh. It can be seen that the ratio of total installed generating capacity to peak load is 1.6, indicating a significant reserve of installed capacity and confirming the advantages of the interconnected system. The advantages of operating in the interconnected system are further underpinned by the data on the duration of peak load (total energy produced divided by the amount of peak load) which is 6464 hours. The main point worth stressing is that the peak load of the interconnected system is lower than the sum of peak loads of member countries by 6000 MW. This capacity would have to be built, distributed across all systems, if the interconnected system did not exist.

What does the future hold for us? Market opening encourages the growth in electricity trade, bringing along new requirements for transmission network operation and development. Currently underway are preparatory activities for further expansion of the UCTE system to include Turkey and the former Soviet Union (UPS/IPS) and under consideration is further expansion of the UCTE system in Africa.

A simple current circuit from the 1888 Tesla's invention of polyphase alternating currents has been constantly expanding over the past 118 years all over the globe, connecting countries and continents to bring people light and all the comforts of electricity, and the expansion of this ingenious invention is continuing into the future.

It may also happen that Tesla's idea of wireless transport of large quantities of energy over large distances using outer space becomes a reality.

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Zagreb, Croatia
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Ericsson Nikola Tesla: Following Tesla's Vision

It is not necessary to answer the question concerning to whom we owe today's way of living, but it is possible. Among the 19th century visionaries and scientists who set the foundations for the present – day standards of living there is a genius mind that stands out. The rich scientific heritage bestowed to humanity by Nikola Tesla (1856 – 1943) has been incorporated in our daily lives in so many ways that we use it hundreds of times a day without even being aware of it.

This year is the Year of Nikola Tesla, the year in which we remember and appreciate this great man, his discoveries and inventions.

He indebted the humanity by his inventions in the field of alternating current, the principle of rotating magnetic field and the improvements of induction motor and fluorescent lighting. By his series of about 700 of inventions he pointed way for the development of the modern civilization.

Tesla's dream comes true

Tesla was a visionary genius. There aren't many of them. And he was willing to give his life to his visions. And for that reason he probed deeply into the secrets of nature and gave us the contributions that he did.

In 1909, Guglielmo Marconi was awarded a Nobel Prize for his development of radio. The history books began to refer to him as "the father of radio."

Nikola Tesla is now credited with having invented modern radio; the Supreme Court overturned Marconi's patent in 1943 in favor of Tesla.

We still use radio in our everyday life, but the more important fact is that when we use the mobile phone. The mobile telephony made the dream about communication anytime, anywhere comes true. The basic modern human needs: mobility, availability and speed are satisfied.

It is impossible to find an answer to the question whether the progress of the mankind accelerated the development of communications, or whether the need for more effective ways to communicate set the path of human progress. The development of the human society and communications go hand in hand and it is neither necessary nor possible to separate them.

Today, Ericsson Nikola Tesla is a provider of total ICT solutions and member of the Ericsson group. The company's activities incorporate the entrepreneurship of Lars Magnus Ericsson and the visionary spirit of Nikola Tesla. Its name reminds the community of these two great men who contributed to the foundation of the new communications era. This described powerful combination has brought value to Croatia and to Ericsson as well as to our customers who will substantially benefit from that combination.

Our work approach has always been founded on innovativeness and flexibility and implied investigating the limits of current truths and trends. It seems to be quite natural for us to promote the greatness of Nikola Tesla and to provide opportunities for young specialists to participate in setting global technology trends. I sincerely believe that Nikola Tesla himself would be proud to know that in his old homeland there are research and development and also expert knowledge centers that successfully develop modern information and communication technologies. Ericsson Nikola Tesla endeavors to follow Tesla's lead on the way to prosperity. As a member of global Ericsson we participate in searching the possibilities to create better life for all people, an objective, I believe, worthy of Tesla and his legacy.

Inventions, Research and Development

The company has always tried to incorporate the fundamental features/qualities that Nikola Tesla cherished – knowledge, creativity, openness to new, different solutions, discipline, ambition and investigative approach to the world around us – in its everyday activities. Almost half of our employees work in research and development, we have growing responsibilities within the Ericsson Group, and several innovative solutions provided by our specialists resulted in /found their place in a widened corporate portfolio.

Based on outstanding results achieved in the preceding years the company has obtained higher responsibilities in the internal Ericsson market in the field of research and development and in the Global Service Delivery Center. For that reason the company employed 340 new associates in the last two years and this employment trend should be continued during 2006.

Ericsson Nikola Tesla now has some 1300 employees, 87% of them being college graduates, mostly electrical engineers. They are motivated, flexible and promising young professionals who have willingly adopted the philosophy of lifelong learning.

In view of current market competition the ability/capacity to produce innovative solutions has become a key distinctive feature between successful and less successful companies. Modern companies, among them the Ericsson corporation as well, have adopted the organizational culture that cherishes innovativeness as a strategic guideline so that research and development activities are fundamental to their market position.

However, modern innovators cannot successfully work independently like Nikola Tesla. Innovative development should be supported by organized activities, by a process with precisely defined and planned measures taken by teams built of experts and innovators. Such an Innovations Management System has been implemented in Ericsson Nikola Tesla.

The Research and Development Center of Ericsson Nikola Tesla enjoys a high reputation in the Ericsson Corporation, because of its expert resources and the complexity of projects and areas the Center deals with. The responsibilities assigned to the R&D Center range from the design of signaling solutions for fixed and mobile telephony based on AXE platform, to the design of new platforms, and to integration and verification services. The company has a modern laboratory for testing the 2G and 3G functionality, with installed mobile network switching nodes, with a comprehensive radio access network for GSM and WCDMA systems, with support nodes and testing tools.

When defining research and development objectives special attention is paid to current market trends so that all company projects are oriented to meeting the communication needs of end users and to improving the general standard of living. I wish to emphasize that the R&D Center is active/engaged in technologically and commercially highly promising areas and strategic projects relating to the company's core business. Accordingly, the main task of the research teams is to create new ideas, design the prototypes and let the development units further improve them, with the commercial phase to follow. Consequently, research activities of the R&D Center are the driving force for much of company business. Within the R&D Center the associates specialized in research and development of information and communication solutions and services deal with location-based services (LBS), networked virtual reality, agent and GRID technologies, remote software support maintenance and the implementation of the Bluetooth technologies in mobile access.

Ericsson Nikola Tesla today

In 2006 when the 150th anniversary of the birth of Nikola Tesla is celebrated in Croatia and worldwide, the company has initiated several independent projects and established the Nikola Tesla Scholarship Funds for outstanding individuals to support their postgraduate studies in applied communication technologies or communication technologies development. With this scholarship, with research and development activities and expert centers, Ericsson Nikola Tesla endeavors to contribute additionally to making Croatia a knowledge society.

Professional expertise is indispensable in research and development. For that reason Ericsson Nikola Tesla permanently collaborates with academic and scientific institutions home and abroad. Company specialists take part in national and international conferences with reports and presentations and have articles published in professional journals, thus promoting the company both as the place producing new ideas in communication and information technologies and to participate and contribute in telecommunications development processes globally.

Ericsson Nikola Tesla as integral part of global Ericsson family, with global presence in more than 140 countries, is able to contribute to an all-communicating world and share the vision of the great thinkers, such as Nikola Tesla, to make people's life easier and richer, providing affordable communication to all. We believe that future belongs to Nikola Tesla and to us as well.

“Marie Curie Workshop 2006 in Croatia and Serbia”

October 8 – 10, 2006, Zagreb and Belgrade, Croatia and Serbia

EUROPEAN COMMISSION
RESEARCH DIRECTORATE-GENERAL

MARIE CURIE ACTIONS

Celebrating Nikola Tesla

Marie Curie Workshop 2006

Hereby I certify that

Mirta Herak

attended the Marie Curie Workshop "Celebrating Nikola Tesla" held in Zagreb and Belgrade from 7-11 October 2006 and presented a poster on the theme:

MAGNETIC PROPERTIES OF Cu_3TeO_6 - SYSTEM WITH NOVEL SPIN LATTICE

Brussels, 26 October 2006

Georges Bingen
Head of Unit
Marie Curie Actions - Fellowships

Address by Commissioner Prof. **Janez Potočnik**, Ph.D.

Marie Curie Workshop Zagreb & Belgrade Celebrating Nikola Tesla

7 – 11 October 2006

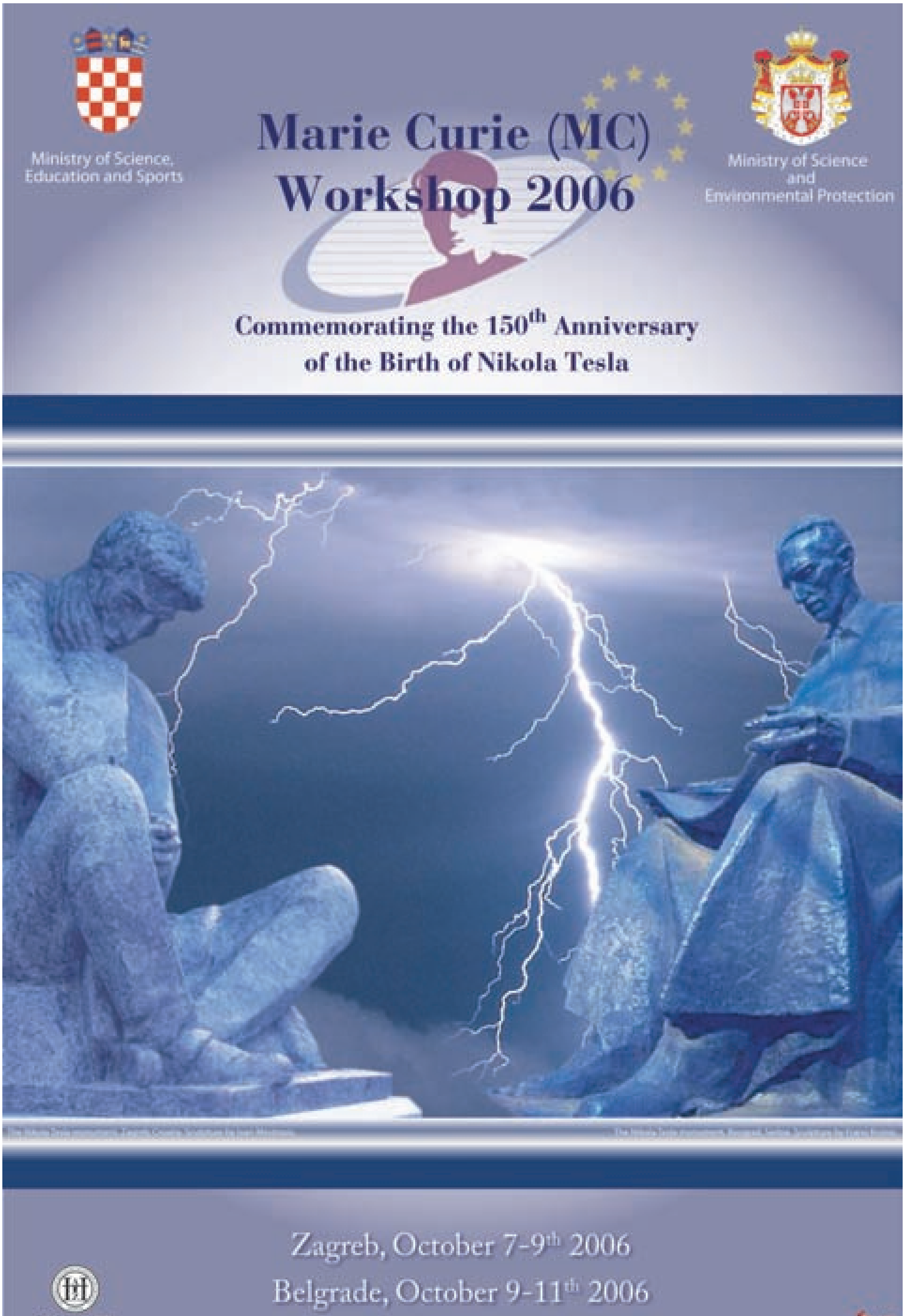
Nikola Tesla was a remarkable, innovative scientist whose groundbreaking achievements and discoveries changed the research landscape for future generations.

In October this year the Croatian and Serbian governments in co-operation with the European Commission have organised a workshop to celebrate the legacy of this outstanding role-model.

As a reflection of Tesla's contributions to science and innovation, the workshop will be multidisciplinary and cover engineering, physics, mathematics and information sciences, as well as related key issues such as intellectual property and patents.

Marie Curie fellows work in the forefront of research and technology including the broad range of disciplines pioneered by Tesla. This workshop will provide a unique view of the state of the art in these disciplines and enable participants to exchange knowledge, foster collaboration and explore future career paths.

I welcome this exciting initiative and invite you to participate.


Ministry of Science, Education and Sports
Marie Curie (MC) Workshop 2006
Ministry of Science and Environmental Protection
Commemorating the 150th Anniversary of the Birth of Nikola Tesla
Zagreb, October 7-9th 2006
Belgrade, October 9-11th 2006
Croatian Academy of Engineering
Photo and design HP

Letter from **Raffaele Liberali**

Director of Marie Curie Actions, to Marie Curie Fellows

Dear Marie Curie Fellow,

Encouraged by the success of Marie Curie workshops and conferences, I would warmly invite you to participate in the Marie Curie European Scientific Workshop 2006, dedicated to the 150th anniversary of the birth of Nikola Tesla. This workshop is organised as part of the training within your fellowship and will take place from 7-11 October in Zagreb, Croatia and Belgrade, Serbia.

The main purpose of the Tesla Workshop is to provide a forum for Marie Curie Fellows from across Europe, working in the area of engineering, physics, mathematics and information sciences to exchange their scientific knowledge and mobility experiences. As well as the opportunities to present their work in oral or poster form, fellows will be expected to participate in sessions related to key transferable skills such as promoting technology transfer and IPR management. This event will also provide opportunities for the Fellows to learn about and discuss the various possibilities to enhance their career prospects within the European Research Area and beyond. Moreover it will be a unique chance for them to build scientific networks with researchers working in similar domains in the Western Balkans as well as with researchers from elsewhere in the EU.

Workshop participants will be able to develop communication and other complementary skills by presenting research results to a mixed audience of postgraduates, postdocs, senior academics and captains of industry from a range of subdisciplines. There will also be the opportunity to exchange views with policy makers, journalists, and the European Commission. The success of the workshop will thus depend to a large extent on the active participation of the Marie Curie Fellows.

Participation is open to all Fellows currently benefiting from one of the following Marie-Curie Actions: *Intra-European Fellowships, Outgoing International Fellowships and Incoming International Fellowships, Return and Re-integration Fellowships*, *Research Training Networks, Host Fellowships for Early Stage Training and Host Fellowships for Transfer of Knowledge*, *Marie Curie Teams and Chairs,* or any of the corresponding Marie Curie action of the former 5th Framework Programme.

The number of places available at the conference is limited. Places will be allocated on a first-come, first-served basis. Upon registration, all Fellows are required to submit an abstract of their research project for a possible poster or oral presentation. Selection of these presentations will be made by the organisers on the basis of the quality and creativity of the abstract provided.

For registration and submission of your abstract please use the on-line facility available at the following web sites:

www.hatz.hr/MarieCurie2006 or http://www.mntr.sr.gov.yu/MarieCurie2006.

Please note that the conference fees and the travel costs should be charged to the research funds already allocated to your host institution as part of your Marie Curie Fellowship.

I look forward to seeing you in Zagreb and Belgrade!

Yours sincerely,

Raffaele LIBERALI
Director

"Marie Curie 2006" registrated participants

Number	Name and surname	Country	MC Number	Position
1.	Juan de Dios Zornoza	France, IFIC- UW-Madison		Researcher
2.	Mercedes Vila	Portugal, University of Aveiro		Researcher
3.	Mohammad Ohidul Alam	UK,Greenwich University		Researcher
4.	Thomas Kreuz	Italy, Instituto dei Sistemi Complessi	fp6 EIF	Researcher
5.	Angela Brett	Switzerland, CERN	fp6 EST	Researcher
6.	Sakari Tiuraniemi	Switzerland, CERN	fp6 EST	Researcher
7.	Guggi Kofod	Germany, University of Potsdam, ACMP	fp6 EIF	Researcher
8.	Catarina Ferreira	Italy, ENEL	fp6 EST	Researcher
9.	Bernd Baufeld	Belgium, MTM, Katholieke Universiteit Leuven	fp6 EIF	Researcher
10.	Christina Erlwein	UK, Brunel University	fp6 EST	Student
11.	Martyn Fletcher	Czech, Czech Technical University	TOK IAP	Researcher
12.	Roisin Ni Chuimin	UK, University of Manchester	fp6 EST	Student
13.	Agnieszka Molendowska	UK, University of Strathclyde	fp6 EST	Researcher
14.	Christos Christoglou	France, CIRIMAT / CNRS	fp6 EIF	Researcher
15.	Gaelle Kerognou	The Netherlands, Thales Nederland	fp6 EIF	Researcher
16.	Jaroslav Sedlacek	Germany, Institute of Ceramics in Mechanical Engineering	fp6 EIF	Researcher

Number	Name and surname	Country	MC Number	Position
17.	Dmytro Verbylo	UK, Queen Mary University of London	fp6 IIF	Researcher
18.	Urszula Stachewicz	The Netherlands, Philips Research Laboratories	fp6 EST	Researcher
19.	Zsuzsanna Major	Germany, Max-Planck-Institute	fp6 EIF	Researcher
20.	Rehman Attiqur	Switzerland, CERN	fp6 EST	Student
21.	Giusy Scalia	Germany, Max Planck Institute	fp6 EIF	Researcher
22.	Oliver Stelzer – Chilton	UK, University of Oxford	fp6 EIF	Researcher
23.	Eletherios Goulielmakis	Germany, Max Planck Institute	fp6 EIF	Researcher
24.	Manuel Gonzalez Garcia	France, Observatoire de Paris	fp6 EST	Student
25.	Dunja Potočnik	Croatia, Institute for Social Research		Student
26.	Christine Lisetti	France, Institut Eurecom	fp6 IRG	Researcher
27.	Suzana Karabaić	Croatia, Ministry of Sc., Edu., and Sports		NCP
28.	Emmanuel Wirth	The Netherlands, Institute for Energy	fp6 EST	Researcher
29.	Markus Hennrich	Spain, ICFO	fp6 EIF	Researcher
30.	Ivan Šamija	Croatia, Sisters of Mercy University Hospital		Researcher
31.	Danijela Dolenec	Croatia, Institute for Social research		Researcher
32.	Vlatka Petrović	Croatia, Institute Ruđer Bošković		Supervisor

Number	Name and surname	Country	MC Number	Position
33.	Andreea Serbescu	UK, University of Sheffield	fp6 RTN	Researcher
34.	Višnja Gaurina Srček	Croatia, Faculty of Food Technology and Biotechnology		Researcher
35.	Mirta Herak	Croatia, Institute of Physics		Student
36.	Kristina Sariri	Croatia, Institute of Physics		Researcher
37.	Milan Vujanović	Croatia, Faculty of Mechanical Engineering and Naval Arch.		Researcher
38.	Renato Markovinović	UK, Schlumberger UK	fp6 RTN	Researcher
39.	Bartolomiej Kunecki	Norway, The Norvegian University of Science and Techn.	fp6 EIF	Researcher
40.	Dejan Drajić	Serbia, Ericsson d.o.o.		Large Enterprise
41.	Nhien An Le Khac	Ireland, University College Dublin	fp6 TOK IAP	Researcher
42.	Julia Lobera	UK, Loughborough University	fp6 EIF	Researcher
43.	Karine Pillet	The Nedherlands, Thales Nederland	fp6 IHF	Researcher
44.	Vladimir Čakarević	Serbia, ETF		Student
45.	Ilija Batas Bjelić	Serbia, Faculty of EE Belgrade		Student
46.	Igor Stamenković	Serbia, Faculty of Electrical Engineering		Researcher
47.	Daura Carballo	Ireland, University of Limerick	fp6 EST	Student

Number	Name and surname	Country	MC Number	Position
48.	Fernando G. Fermoso	The Netherlands, Wegeningen University	fp6 EXT	Researcher
49.	Vilim Žlender	Croatia, Institute for Medical Research and occup. Health		Researcher
50.	Marija Surić Mihić	Croatia, Institute for Medical Research and occup. Health		Researcher
51.	Emil Varga	Serbia, School of Electrical Engineering, Belgrade		Student
52.	Ivana Milovanović	Serbia, Faculty of Electrical Engineering, Belgrade		Student
53.	Marko Stanković	Serbia, School of Electrical Engineering, Belgrade		Student
54.	Nebojša Malešević	Serbia, Faculty of Electrical Engineering, Belgrade		Student
55.	Jovan Vujnić	Serbia, School of Electrical Engineering, Belgrade		Student
56.	Miloš Stefanović	Serbia, Faculty of Electrical Engineering, Belgrade		Student
57.	Žarko Celičanin	Serbia, Faculty of Electrical Engineering, Belgrade		Student
58.	Željka Mesić	Croatia, Faculty of Agriculture, Zagreb		Researcher
59.	Marko Mihailović	Serbia, Faculty of Electrical Engineering, Belgrade		Student

Number	Name and surname	Country	MC Number	Position
60.	Fran Supek	Croatia, Institute Ruder Bošković		Student
61.	Vladimir Kovačević	Serbia, Faculty of Electrical Engineering, Belgrade	fp5 TS	Student
62.	Marko Ćosić	Serbia, School of Electrical Engineering, Belgrade		Student
63.	Pavle Ilić	Serbia, Faculty of Electrical Engineering, Belgrade	fp5 TS, RTN	Student
64.	Zoran Štefanić	Croatia, Institute Ruder Bošković		Researcher
65.	Miloš Gulić	Serbia, School of Electrical Engineering, Belgrade		Student
66.	Jelena Grujić	Serbia, Institute of Physics, Belgrade		Student
67.	Marija Mitrović	Serbia, Institute of Physics, Belgrade		Student
68.	Marko Ukrainczyk	Croatia, Institute Ruder Bošković		Researcher
69.	Ivan Koralt	Serbia, Institute of Physics, Belgrade		Student
70.	Branko Petrinec	Croatia, Institute for Medical Research and occup. Health		Researcher
71.	Marin Prcela	Croatia, Institute Ruder Bošković		Student
72.	Novica Paunović	Serbia, Institute of Physics, Belgrade		Researcher
73.	Marija Milosavljević	Serbia, Institute of Physics, Belgrade		Researcher

Number	Name and surname	Country	MC Number	Position
74.	Branislav Cvetković	Serbia, Institute of Physics, Belgrade		Researcher
75.	Robert Vianello	Croatia, Institute Ruder Bošković		Researcher
76.	Nikola Basarić	Croatia, Institute Ruder Bošković		Researcher
77.	Nenad Vranješ	Serbia, Institute of Physics, Belgrade		Researcher
78.	Nevena Puac	Serbia, Institute of Physics, Belgrade		Student
79.	Hrvoje Štefančić	Croatia, Institute Ruđer Bošković		Researcher
80.	Vladimir Malić	Serbia, Faculty of Electrical Engineering, Belgrade		Student
81.	Vinko Zlatić	Croatia, Institute Ruđer Bošković		Student
82.	Dalibor Merunka	Croatia, Institute Ruđer Bošković		Researcher
83.	Leonid Shirkov	Poland, Warsaw University, Faculty of Chemistry	fp6 EST	Researcher
84.	Duško Borka	Serbia, Vinča Institute of Nuclear Science, Belgrade		Researcher
85.	Ana Šantić	Croatia, Institute Ruđer Bošković		Researcher
86.	Ivan Balog	Croatia, Institute of Physics		
87.	Livia Puljak	Croatia, University of Split Medical School		Researcher
88.	Maro Jelić	Croatia, University of Dubrovnik		Researcher

Number	Name and surname	Country	MC Number	Position
89.	Ksenija Todorović	Croatia, Primary School – Retkovec		Student
90.	Louisa Reissig	UK, University of Edinburg	fp6 EST	Student
91.	Dragiša Žunić	France, Ecole Normale Superieure de Lyon	fp6 EST	Student
92.	Bodh Raj	Germany, University of Duisburg – Essen	fp6 IIF	Researcher
93.	Uwe Dorner	UK, University of Oxford	fp6 EIT	Researcher
94.	Marko Delimar	Croatia, Faculty of Electrical Engineering and Comp.		Researcher
95.	Hilmi Volkan Demir	Turkey, Bilkent University	fp6 IRG	Project Coordinator
96.	Goran Topić	Croatia, Institute Ruđer Bošković		Researcher
97.	Georgios Ellinas	Cyprus, University of Cyprus	fp6 IRG	Researcher
98.	Milan Milošević	Serbia, Faculty of Electrical Engineering, Belgrade.		Student

PROGRAMME ZAGREB

Saturday 7th October

14:00-18:00	Registration (Hotel International, 24 Miramarska St. Zagreb)
18:00-19:30	Guided tour: Zagreb and surroundings
19:30-21:00	Welcome Reception - Hotel International

Sunday 8th October

8:00-9:00	Set up posters (Faculty of Electrical Engineering and Computing (FEEC), University of Zagreb, 3 Unska St. http://www.fer.hr)
9:00-9:20	Opening
	Chair: Zlatko Kniewald, President Croatian Academy of Engineering (CAE), Slobodan Uzelac, State Secretary, Ministry of Science, Education and Sports Republic of Croatia (MSES)
Opening Address	Vedran Mornar, Dean of FEEC Aleksa Bjeliš, Rector of the University of Zagreb
9:20-11:00	Keynote speeches & Roundtable.
	Chair: Radovan Fuchs, Deputy Minister, MSES Zlatko Kniewald: Tesla's scientific contribution and its European dimension
Speakers	Nikola Rajaković, Faculty of Electrical Engineering, Belgrade, Serbia: Tesla's work and its impact on modern transmission systems.
	Juraj Bartolić: European School of Antennas
	Tomislav Petković: A Trilogy on Tesla
	Karolj Skala: Analogue and Digital Grid
	Questions and Answers
11:00-11:30	***Coffee/Tea/ Biscuits*** Poster session
11:30-13:30	"Tesla's Heirs". **Chair**: Zrinka Kovačević, Deputy Minister, MSES

Oral Presentations by 8 registered Marie Curie / local fellows

13:30-15:00	Informal Lunch / Poster Session
15:00-16:45	**Parallel Training Workshops**: Moderator Stanko Tonković Vice-president CAE
	Communicating science: Jasminka Lažnjak
	Alternative Careers: Zdenko Kovač
	How to write a successful research funding proposal: Uwe David, Germany
	Managing IPR: Željko Topić, Director State Office for Intellectual Property Protection (SOIPP), Ljiljana Kuterovac Deputy director SOIPP, Vice Šoljan, manager, director "Ecological Engineering", Poreč Thomas Ruddy, AEA Technology England
	Academic writing: Vlatko Silobrčić
	Entrepreneurship: Vedran Bilas
16:45-17:00	***Coffee/Tea/ Biscuits***
17:00-18:00	**Mobility Experiences**, Marie Curie Fellows, Charter & Code / Scientific Visa **Chair:** Gordana Prutki-Pečnik, Counsellor MSES

Speakers	Christos Christoglou, Secretary General of Marie Curie Fellowship Association (MCFA) Member of DG Research European Commission
18:00-19:30	Poster & networking session
19:30-20:00	Pre-conference dinner drinks, hotel International
20:00	***Dinner, Hotel International***

Monday 9th October

10:00-11:45	**"FP7: Unlocking research potential in Central and Eastern Europe / 3rd country participation":**
	Chair: Dražen Vikić-Topić, State Secretary MSES, Kristian Toivo Ericsson Inc.
Speakers	Janez Potočnik, EU Commissioner for Research
	Ivan Videnović, Assistant Minister, Ministry of Science and Environmental Protection, Republic of Serbia
	Dragan Primorac, Minister MSES
10:45-11:00	***Coffee/Tea/Biscuits-Press Conference***
	Chair: Jasna Kniewald, Head International Cooperation CAE, Branka Zovko-Cihlar, Vice-president CAE
Speakers	Kristian Toivo, Ericsson Inc., Sweden: Science and Technology Management in South and Eastern Europe
	Roko Žarnić, Faculty for Civil and Geodetic Engineering, Ljubljana, Slovenia: Focus area cultural heritage within ECTP
	Jure Radić, Faculty of Civil Engineering, Zagreb, Construction Technological Platform for FP-7- Our experience and future development
	Questions and Answers
11:45-12:00	***Coffee/Tea/ Biscuits***
12:00-13:30	**"Tesla's Heirs"**.
	Chair: Andrea Tomljenović, Deputy Minister MSES, Vladimir Medved, Fac. Kinesiology and CAE Member

Oral Presentations by 7 registered Marie Curie / local fellows

14:00	Travel to Belgrade by bus in organization GLOBTOUR Zagreb d.o.o.,(packed lunch onboard)
18:00/19:00	Arrival in Belgrade, Hotel Intercontinental, Vladimira Popovića 10, 11000 Belgrade

PROGRAMME BELGRADE

20:00	Social event / Dinner (Hotel Intercontinental)

Tuesday 10th October

8:15	Departures of buses from the hotel to the University of Belgrade, Studentski trg 1 (http://www.bg.ac.yu)
8:30	Set up posters
9:00	Opening
	Chair: Ivan Videnović, Assistant Minister, Serbian Ministry of Science and Environmental Protection
	Opening address: Aleksandar Cvetanović, Vice-rector of the Belgrade University

	1st Morning session: Research and Innovation
Speakers	Janez Potočnik, European Commissioner for Research
	Aleksandar Popović, Minister, Serbian Ministry of Science and Environmental Protection
	Dražen Vikić-Topić, State Secretary, Croatian Ministry of Science, Education and Sports
	Aleksandar Marinčić, Serbian Academy of Sciences and Arts: Tesla's contribution to the radio technique
	Manfred Horvat, Vienna University of Technology: Research and innovation as an integration tool
	Questions and Answers
10:45-11:15	***Coffee break & Poster session***
11:15-13:15	**2nd Morning session: Tesla's Heirs**
	Chair: Jean-Paul Brasselet, France
Oral presentations by 8 registered Marie Curie / local fellows	
13:15-14:45	***Buffet Lunch & Poster session***
14:45-16:30	**Afternoon session: FP 7, research careers and the future of scientific cooperation in the region**
	Chair: Manfred Horvat, Vienna University of Technology, Vienna, Austria
Speakers	George Bingen, Head of Policy, Marie Curie Actions, DG Research European Commission: Research careers and the forthcoming FP7
	Peter Mayr, SEE-ERA.NET Coordinator, Centre for Social Innovation, Vienna, Austria: The future of scientific cooperation in the South-East Europe
	Radovan Fuchs, Deputy Minister, MSES Croatia: Croatian experience at FP6 and participation at FP7
	Tania Friederichs, INCO Directorate, DG Research, European Commission: Western Balkan Countries in the forthcoming FP7
	Miodrag Marković, Deputy Director of the Serbian Intellectual Property Office, Serbia: Intellectual property rights at a glance
	Zoran Popović, Centre for Solid State Physics and New Materials, Serbia: Driving research career-the "Schon story"
	Questions and Answers, Round table discussion
16:30-17:00	***Best Poster Award and Closing ceremony***
17:00-20:00	Belgrade sightseeing (guided bus tour). Visit to the Nikola Tesla museum.
20:00	***Conference Dinner***

Wednesday 11th October

07:30	Departure of buses to Zagreb
12:00/13:00	Arrival in Zagreb and departure to final destinations.

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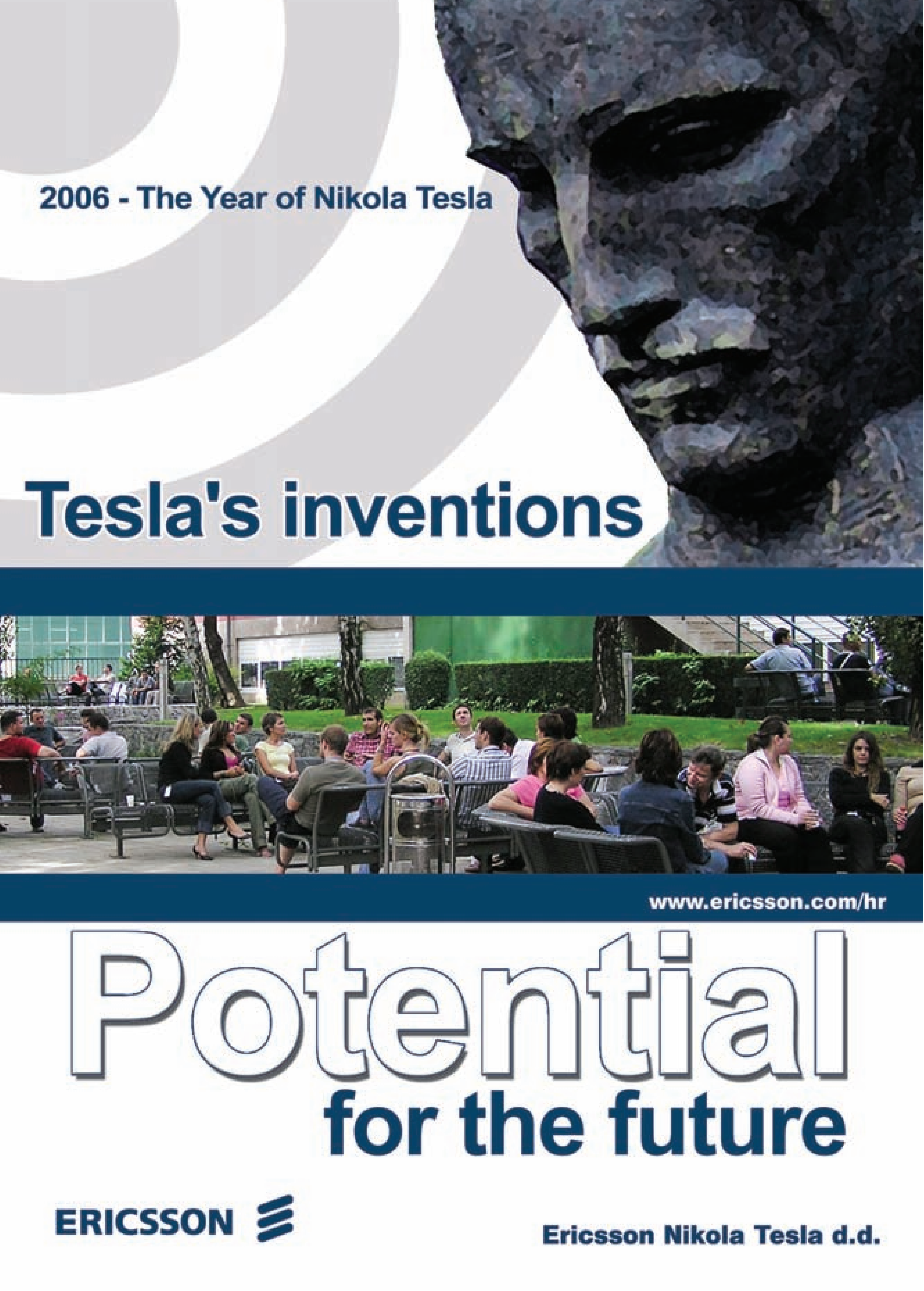
Croatia - Tesla - World

2006 - THE YEAR OF NIKOLA TESLA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Potential
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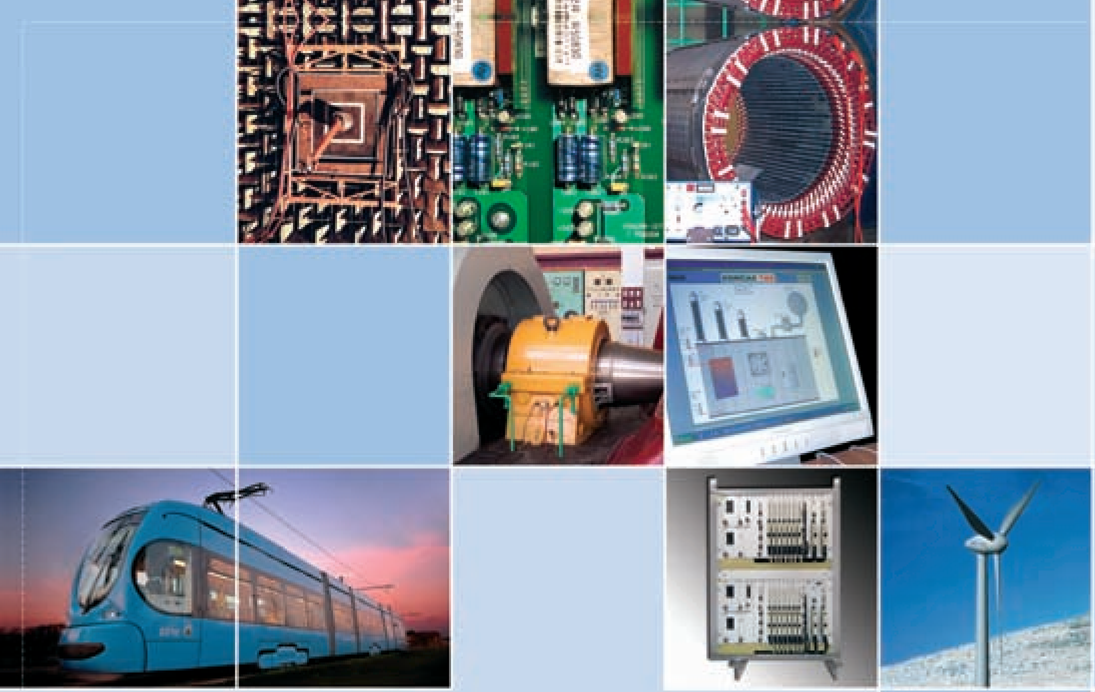
Ericsson Nikola Tesla d.d.



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