Nikola Tesla in Science – Discovery of X-rays

Nikola Tesla u znanosti – otkriće rendgenskih zraka

Stanko Popović
Croatian Academy of Sciences and Arts
Physics Department, Faculty of Science, University of Zagreb, Croatia

Scientific achievements and miraculous inventions have made Nikola Tesla, *the Croatian inventor* (*The New Yorker* 2013), world-famous. Here are several titles out of thousands of books and papers dealing with the life and work of Nikola Tesla that confirm the above statement: *Prodigal Genius–The Life of Nikola Tesla* (J. J. O'Neill, *Ives Washburn* 1944, *Book Tree* 2007); *Tesla–Man out of Time* (M. Cheney, *Simon and Schuster* 2001); *The Man Who Invented the Twentieth Century–Nikola Tesla, Forgotten Genius of Electricity* (R. Lomas, *Headline* 1999); *Wizard–Biography of a Genius* (M. Seifer, *Citadel* 2001); *Tesla–Master of Lightning* (M. Cheney *et al*., *Barnes & Noble Books* 1999); *Nikola Tesla–The Man Behind the Magnetic Field Unit* (A. Rougin, *J. Magn. Reson. Imaging* 2004); *Inventor of Dreams* (B. Carlson, *Scientific American* 2005); *The Fantastic Inventions of Nikola Tesla* (D. Childress, *Adventures Unlimited Press* 1993); *Nikola Tesla–Physicist, Inventor, Electrical Engineer* (M. Burgan, *Minn. Compass Point Books* 2009); *Nikola Tesla and the Discovery of X-rays* (M. Hrabak *et al*., *RadioGraphics* 2008). However, there are some statements about Tesla, given in certain papers, books and encyclopedias, which are not always correct.

Some of the main scientific achievements and inventions of Nikola Tesla (not ordered chronologically) are: alternating current, generators of alternating current, polyphase system, rotating magnetic field, induction motor, electric power distribution and transmission, Tesla Columbus egg, Tesla transformer, wireless transfer of energy, radio remote control vehicle, teleforce, robot, radio, Tesla coil, bifilar coil, Tesla oscillator, current of high frequency and high voltage, lightning rods, arc light system, Tesla turbine, Tesla bladeless turbine, terrestrial stationary waves, telegeodynamics, electrogravitics, X-rays, electronic logic gate... Tesla also contributed much, theoretically and experimentally, in discovering and understanding of several fundamental notions and concepts in physics; however, other scientists were rewarded primacy for that in forthcoming years (V. Paar, *60th Anniversary of Death of N. Tesla*, *Croatian Academy of Sciences and Arts*, 2004): papers on electron in 1891 (discovery of electron by J. J. Thomson in 1897); the idea on electron microscope in 1903 (its construction by E. Ruska 1931-33), X-rays in 1894 (W. C. Röntgen 1895), accelerator of a beam of charged particles in 1891 (construction of cyclotron by E. Lawrence in 1932, linear accelerator by J. Cockroft and E. Walton in 1932), prediction of cosmic rays in 1897 (discovery of cosmic rays by V. Hess in 1912), concept of radar in 1903 (construction of radar in 1934-40), the idea of induced radioactivity in 1899 (experimental discovery by J. F. Joliot, I. Curie in 1934), radio transmission in 1898 (G. Marconi 1901), laser in 1893 (construction of laser by C. Townes, N. Basov, A. Prochorov in 1953-57).

When Guglielmo Marconi made his first ever transatlantic radio transmission in 1901, Tesla stated that he had already described that phenomenon in a series of his patents. In 1943 The Supreme Court of the United States decided to restore the priority of Tesla's patents. In 1960, in honor of Tesla, the *General Conference on Weights and Measures* for the *International System of Units* dedicated the term *tesla*, T, to the SI unit of magnetic field.

Tesla obtained around 300 patents worldwide for his inventions. His patent specifications began like this: "Be it known that I, Nikola Tesla, of Smiljan, Lika, border country of Austria-

Hungary, residing at New York, have invented...", or, "Be it known that I, Nikola Tesla, a citizen of the United States, residing at New York, have invented...".
In 1892 Tesla visited Zagreb and presented a plan for the electrical illumination of the town. On December 17, 1896 Tesla was elected the honorary member of the Yugoslav (now: Croatian) Academy of Sciences and Arts, while on June 29, 1926 he was awarded the honorary doctorate by the University of Zagreb.
Starting in 1894, Tesla experimented with mysterious *shadowgraphs* similar to those that *later* were studied by W. C. Röntgen (Encyclopedia Britannica; N. Tesla, Lecture before the New York Academy of Sciences 1897; *21st Century Books* 1994). Tesla was aware of an unknown radiant energy of *invisible* kind (a *very special radiation*) that had damaged film in his laboratory in the previous experiments (M. Hrabak *et al*. 2008; M. Cheney 2001), later identified as *Röntgen rays* or *X-rays*. Unfortunately, much of his early research was lost when his lab in New York was burnt down on March 13, 1895. Röntgen published his discovery on November 8, 1895. In the beginning of 1896, after hearing of Röntgen's discovery, Tesla proceeded with his own experiments in X-ray imaging, designing a high energy unipolar vacuum tube that had no target electrode; the electrons were accelerated by peaks of the electrical field produced by the high-voltage Tesla coil. Tesla realized that the source of X-rays was the site of the first impact of electrons within the tube, which was either the anode in a bipolar tube or the glass wall in the unipolar tube. In his research, Tesla devised several experimental setups to produce X-rays, that were of much greater power than obtainable with ordinary apparatus. He stated that the cathodic stream was composed of very small particles (*ie*. electrons), and that the produced X-rays were also minute particles (later proved to be electromagnetic radiation quanta–photons). Tesla described his experiments in detail in a series of papers in *Electrical Review New York*, the first paper appearing in March 1896 (March 11, 18, April 1, 8, 22, July 8, Aug 12, Dec 1, 1896; May 5, Aug 11, 1897). Tesla sent his images to Röntgen shortly after he published his discovery. Although Tesla gave Röntgen full credit for his discovery, Röntgen congratulated Tesla on his sophisticated images, wondering how he had achieved such impressive results. Tesla commented on physiological hazards of working with X-rays and gave recommendations for protection (D. Di Santis, *Early American Radiology*, *Am. J. Röntgenol.* 1986). He also described some clinical benefits of X-rays: determination of foreign body position and detection of lung diseases, noting that denser bodies were more opaque to X-rays. He also experimented with reflected X-rays, using different materials as the reflecting surface, and described features of transmitted and reflected rays. Tesla realized that a sharp shadow of an object could be produced at a great object-film distance and with a short exposure time.
Therefore, there is much evidence that confirm the legacy of Tesla in discovery of X-rays, starting with his papers in *Electrical Review*; his lecture before the New York Academy of Sciences in 1897 validated to some degree his primacy in research of X-rays. One will never know who would have won the Nobel prize for the discovery of X-rays if Tesla's work had not been lost in fire. The least one can do is to appreciate his pioneer work in this field (M. Hrabak *et al*. 2008). The nature of X-rays was finally unveiled by Max von Laue in 1912 who performed the experiment of diffraction of X-rays in a crystal.