NIKOLA TESLA
FATHER of ALTERNATING CURRENT

by Brian Roberts, CIBSE Heritage Group

Nikola Tesla, 1856-1943

Nicola Tesla was born in Smiljan, Lika, a borderland region of Austro-Hungary (modern day Croatia). His “father was an eloquent clergyman in the Greek Church. His mother was a woman of inherited ingenuity, and delighted not only in skilful work…..but in the construction of ….machinery required in a rural community.”

After attending state schools he continued in higher education, graduating in 1873 and devoted himself to experimentation, especially in electricity and magnetism before entering the Polytechnic at Gratz hoping to become a Professor of mathematics and physics.
From left: Milutin Tesla, Nikola’s father, Milka, Angelina and Marica, Tesla’s sisters

Nikola Tesla in traditional costume

Tesla in 1879 at age twenty-three
Tesla gained experience in electrical engineering before emigrating to the United States in 1884 and working for Thomas Edison in New York City. Edison refused to accept new ideas and, probably because of his poor understanding of mathematics, could not fully comprehend the workings of the alternating current system. It appears that after Tesla was not given a promised bonus he resigned, which turned out to be a big mistake on Edison’s part.

George Westinghouse, who made his fortune by inventing the railway air brake, saw the possibilities in alternating current systems and bought up Tesla’s and various European patents and went into competition with Edison who waged a vitriolic campaign against AC. The battle ended in defeat for Edison since DC systems could only supply customers up to a mile from the power station while high voltage AC could be transmitted several hundred miles.
The World’s Fair (Colombian Exposition) in Chicago, 1893 with lighting by Westinghouse

The Westinghouse Alternating Current Switchboard at the Chicago Fair
Westinghouse display at the 1893 World’s Fair featuring the Tesla Polyphase System
Tesla in 1885 at age twenty-nine
Tesla's AC Motor (from Cheney & Uth)

Tesla's most famous invention, the AC motor, has been called a technological advance equivalent to the wheel. The analogy is justified by the immense impact the two discoveries had on subsequent technological development. Unlike the wheel, however, the most important moving part of Tesla's AC motor was something invisible and insubstantial: a magnetic field.

All electrical motors, AC and DC, operate on the same basic principle: a magnetized part that turns (rotor) aligns itself with another magnetized part that doesn't turn (stator). Usually both parts are electromagnets, so that their north and south poles can be reversed simply by changing the direction of current running through them. If pole changes are properly timed, the rotor chases around trying to bring itself into alignment with successive stator poles but never catching up. The rotor's own momentum keeps it in the chase, seeking each "next" pole; otherwise it might just twitch back and forth as nearby poles reversed.

Motors before Tesla operated on direct current, and their limitations in commerce and industry had already become troublesome. Because the supply current travels in one direction only, it must be mechanically switched to run first one way and then the other through a motor's pole projections—in DC motors devices called "commutators" do this.

In Tesla's AC motors, by contrast, the field's poles are always in play, moving in steady, invisible arcs around the stator faces. Mechanical contacts, too, can be done away with by using induction to build and reverse the rotor fields. And AC devices operate, of course, without need of converting their source of power.

Tesla didn't merely make AC theoretically feasible; he created a completely operational technology. He patented over a score of designs: motors to overcome high resistance on starting, to run with variable loads, at constant speeds or at variable speeds—anything that might reasonably be asked of electrical engineering. This motor and related AC technology launched modern electrical industry and, essentially, the twentieth-century way of life.
First factory of the Westinghouse Electric Company in Pittsburgh

Tesla’s demonstration test bench with his Egg of Columbia which stood on end when the table on which it sat was magnetically excited by AC
Lord Kelvin (centre) visited Westinghouse in 1897 and recognised the advantages of AC

Niagara generator under construction at Westinghouse in Pittsburgh, 1894
The first Niagara generator at the Falls Power Station, 1895

The first three Niagara Falls generators went on line on 16th November, 1896
The Edward Dean Adams Power Station at Niagara Falls with ten 5000 horsepower Tesla-Westinghouse AC generators

Niagara Falls Power Station which transmitted AC at 22 kV to Buffalo some 22 miles away and later to New York a distance of over 300 miles
A large Tesla Motor

The end of the “Battle of the Currents” (AC versus DC)
A notice similar to that earlier produced by Edison relating to DC lighting

Another view of a large Tesla AC motor
The Tesla Turbine or “Turbo Pump”

Tesla experimenting with a million volts of man-made lightning
Tesla demonstrating electrical apparatus in 1916

The Tesla Electric Light and Manufacturing Company Stock Certificate
TELESA’S EXPERIMENTS WITH ALTERNATING HIGH VOLTAGE CURRENTS

While in Europe alternating currents with frequencies not exceeding 100 per second were still being studied eagerly for practical applications, reports were received from America in 1891 that most surprising experiments were being carried out there with alternating currents of 15,000 cycles. The initiator of these studies was a Hungarian employed with the Westinghouse Company—Nicola Tesla. With remarkable talent he has conducted experiments and research in a hitherto almost unexplored field: that of alternating currents of extremely high voltage and frequency. He gave an account of his work before the American Institution of Electrical Engineers in New York in a lecture which has since become famous. It made an indelible impression upon the audience, both as account of the brilliant experiments and the completely new vistas it had opened. His work places Tesla among the greatest of our present-day scientists and inventors such as Edison, Graham Bell and Thomson.

When the news of Tesla’s experiments reached Europe, he was approached by the most prominent scientific circles in Britain and France who invited him to repeat his experiments in those countries. These lectures were attended by large and enthusiastic audiences which included men of great authority in the fields of the theoretical and applied sciences. After three hours of lecturing to an enthralled and fascinated audience, Tesla was compelled to admit that he had discussed only part of his research work.

Tesla uses two different types of equipment for generating his alternating high-frequency currents. One is a dynamo with 884 wire coils and an equal number of field magnets rotating at 59 revolutions per minute, thus producing an alternating current of 59,000—19,000 cycles per second. Tesla also uses a special type of transformer. Its primary coil has only a few windings and is connected in series with a spark-gap, a condenser and the secondary winding of a Ruhmkorff-type induction-coil. With the second combination, tensions of half a million volts and scores of thousands of cycles per second can be generated, producing most impressive discharge phenomena in the open air and in glass tubes filled with rarefied air.

In the air, these currents engender electrical fireworks of unprecedented splendour which assume the weirdest shapes, forming luminous fans and plumes of gossamer-like texture. Amazingly enough, these ultra-high voltages are in no way dangerous, thanks to their high frequency. In Berlin, Tesla placed himself between two of his assistants who were almost 15 feet apart, each of them touching one pole of the high-voltage transformer, and when Tesla reached out to them with his two arms, vavy bundles of violet-coloured electric fire shot forth from his fingertips, spreading out to one assistant’s hand and to the other’s forehead. This to the great dismay of some of the spectators, until they noticed that the experiment was harmless and painless.

One of Tesla’s most striking experiments was his demonstration with the 3-foot-long Geissler tubes. For that purpose, two metal bars, 10 feet in length, attached to the floor and ceiling, were connected to the poles of his high-voltage transformer. When Tesla moved two Geissler tubes into the field between the two bars, they became luminous over their entire length without being connected either to the metal bars or to the transformer. In the words of one reporter: “Tesla stood there

“Tesla stood there like the archangel, brandishing the flaming sword!” (1893)

Extract from the French magazine La Nature of 1894
Tesla’s World System (from Cheney & Uth)

TESLA’S LEGACY

This is described in the words of his biographer, Robert Lomas, in his book of 1999:

“Everybody knows that Thomas Edison devised electric light, that Guglielmo Marconi thought up radio and George Westinghouse built the world’s first hydro-electric power station. Everyone knows the facts, but they are wrong.

One man alone dreamt up these things: Nikola Tesla, a Serbian-American scientist, who also invented inter alia the fluorescent light, seismology and a worldwide data communication network which prefigured the internet. He is without doubt this century’s greatest unsung scientific hero.”
Montage of Tesla’s inventions (from Cheney & Uth)
A second montage of Tesla’s inventions (from Cheney & Uth)
Nikola Tesla in 1930 at age sixty-four

Tesla’s coffin in the Cathedral of St John the Divine, New York City, 12th January 1943
N. TESLA.

REGULATOR FOR ALTERNATE CURRENT MOTORS.

A. SCHMID & N. TESLA.
ARMATURE FOR ELECTRIC MACHINES.
No. 417,794.
Patented Dec. 24, 1889.

Fig. 1.
N. TESLA.

APPLAUS FOR PRODUCING ELECTRIC CURRENTS OF HIGH FREQUENCY AND POTENTIAL.

No. 568,176 Patented Sept. 22, 1896.
BIOGRAPHY

1893 *The Inventions, Researches & Writings of Nikola Tesla*, T C Martin: Barnes & Noble (2014 reprint)

------- *N Tesla*, US Patent Office Records

1894 *Tesla’s Experiments with Alternating High Voltage Currents*, p.232, La Nature


2001 *Tesla: Master of Lightning*, Margaret Cheney & Robert Uth, MetroBooks, USA

2007 *Tesla: Master of Lightning*, DVD, PBS (Public Broadcasting Service), America

*May be available only in Region 1, NTSC format*

https://en.wikipedia.org/wiki/Nicola-Tesla

https://en.wikipedia.org/wiki/Alternating-current

See also www.pbs.org/tesla

A complete listing of Tesla’s US Patents with Drawings is available on the internet
POSTSCRIPT & FURTHER READING & VIEWING

THE INVENTIONS, RESEARCHES, AND WRITINGS OF

NIKOLA TESLA

1893
THE MAN WHO INVENTED THE TWENTIETH CENTURY

Nikola Tesla, Forgotten Genius of Electricity

‘Intriguing...puts today’s hype wars into perspective’
GUARDIAN

ROBERT LOMAS

1999
EPILOGUE

New York Memorial Tablet to Nikola Tesla

Nikola Tesla statue at Goat Island, Niagara Falls
Monument at Niagara Falls to Nikola Tesla, standing on top of his AC motor

The SI derived unit the tesla (symbol T) is the standard unit of magnetic flux density.