*Right: Nikola Tesla's invention of AC generators, motors and a power distribution system laid the foundations of modern industry.*

*Edison, pictured with some of his early light bulbs. The two were to become bitter rivals in the AC versus DC controversy.*

# The inventive genius

***Nikola Tesla has been called "possibly the greatest inventor the world has ever known". His discoveries form the basis of modern industry yet he remains one of the least recognised scientific pioneers in history.***

**by J. L. ELKHORNE**

Through the years, power stations have generated as much controversy as electricity. Let us examine the problems men faced a hundred years ago.

The 1870s was an era of gas light and horse-drawn vehicles; what little electricity was used in industry originated on site. Before long, new forms of power generation and transmission would transform the nature of life – and two titans of electrical power would find themselves locked in a mortal combat that came to be known as "the battle of the currents."

The electric light in our homes and business which we take for granted today eluded scientific men for three-quarters of the 19th century. Humphry Davy demonstrated an electric carbon-arc lamp in 1808 but further development awaited a better power source. Then the dynamo emerged in 1831, based on Michael Faraday's discovery of magnetic induction.

The availability of ready power helped progress, but it was not enough. Scores of scientists and inventors tried to capture the elusive principle of incandescence; De La Rive in 1820, De Moleyns in 1841 and J. W. Starr in 1845.

Joseph W. Swan, in England, gave up in 1860 after 12 years of experiments. Arc lamps were developed by various practitioners of the electrical art, and became common in the 1880s.

Thomas Alva Edison superseded Farmer, Brush, Sawyer, Hiram Maxim, St George Lane-Fox, and Wallace. The "Wizard of Menlo Park", already wealthy and famous from previous work, turned his attention actively to the problem in September, 1878. Having witnessed the Wallace-Farmer arc light system, Edison told Wallace: "I do not think you are working in the right direction." He proceeded to work on the problem in his own fashion for two nights and said: "I discovered the necessary secret, so simple that a bootblack could understand it."

Edison realised that intense arc lights could not fulfill the requirements of ordinary household use. He also recognised that a corollary of practical home lighting was a distribution system running from a central station.

He outlined his grand plan – to electrify New York City – to a reporter and reckoned he could have his electric light invention finished in six weeks. His electric distribution system would duplicate the gas-distribution industry which then lit the cities. The true value in his skill lay not in developing an incandescent lamp, so much, as in the

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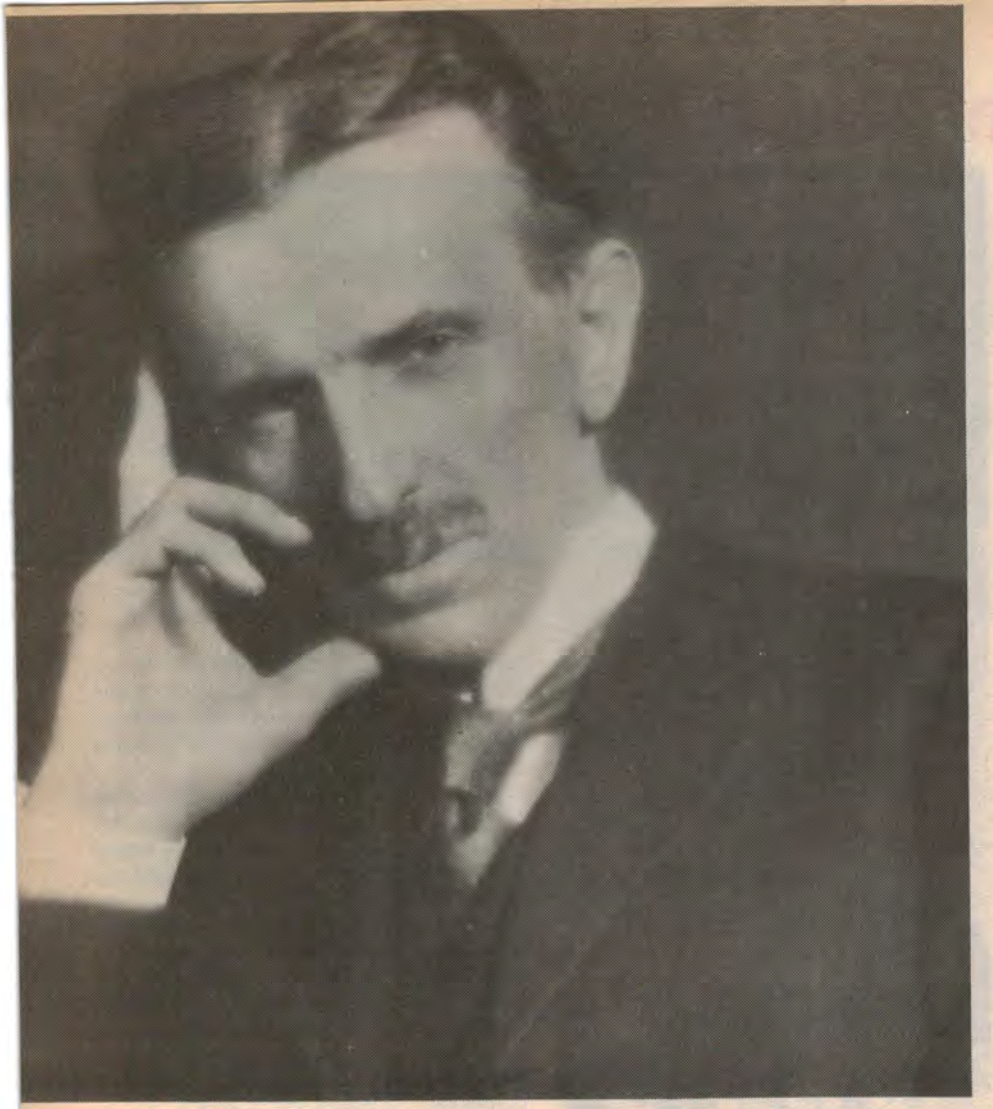

# of Nikola Tesla

concept of electric distribution.

Putting the cart before the horse, Edison launched an elaborate press campaign, essentially stating that the problem of electric lighting had been solved. In October, he carefully demonstrated a platinum-wire lamp. He had realised early on the necessity of a good vacuum for his lamp. He also knew, secretly, that his platinum-wire lamp was not the answer. Had he not turned it off after a short period of illumination, it would have burned out. But his showmanship convinced the public that the time had come.

Years later, one of his associates remarked: "Edison got himself into trouble purposely, by premature publication so that he would have a full incentive to get himself out of trouble."

That trouble of his own making brought him the backing of a syndicate of financiers. Even though no electric distribution system stood ready, gas company shares dropped some 12% during this hectic time. The capitalists who took a paper loss quickly lined up to support Edison in his quest for success and profit with the new idea.

By April, 1879, Edison found his platinum-wire lamps quite encouraging, "burning an hour or two" but tried many other substances. A demonstration for his backers was not a success, however. One of the financiers remarked that Edison "would have been better off to spend a few dollars for Starr's book on carbon vacuum lamps, rather than coming to the same stopping point after spending $50,000."

The breakthrough came on October 21, 1879, with a test of carbonised ordinary cotton thread – Coats cord No. 29. Notebooks attest to a continuous run of 13½ hours. Edison coined the term *filament* for his carbonised threads, and before long, had a filament of Bristol cardboard that burned 170 hours.

Although Menlo Park neighbours and railway passengers out of New York had seen brilliant lights at night, the public announcement of success waited until December 21, 1879. Almost three years

*Tesla's first work was with telephones somewhat less advanced than this 1900 model.*

of work on the principles of distribution followed. Edison's Pearl Street power plant officially opened on September 4, 1882 and initially had 59 household subscribers. The Pearl Street Station generated electricity from steam, but a hydroelectric plant also started operation in Appleton, Wisconsin in that year.

Had Thomas Alva Edison but known it his troubles were just beginning. His "marvel of the century" would soon prove to be an expensive white elephant, obsolescent almost before it began, and surpassed within a decade by a man whom Edison would characterise as a continental playboy.

Nikola Tesla, Croatian-born engineer and scientist, had long sought the secret of alternating current. In February of 1882, a fateful year, Tesla hit upon the brilliant concept of the rotating magnetic field.

Alternating current seemed to ordinary men of the day as nothing more than a laboratory curiosity. Just as with the electric incandescent light, scores of inventors had tried and failed with it. To understand why Nikola Tesla succeeded, analysis of the man and his time is worthwhile.

Tesla was born on the night of July 9-10, 1856, the second son of a Serbian Orthodox clergyman. His birthplace, Smiljan, Lika, Croatia, lies within the borders of modern Yugoslavia.

Nikola's father, Milutin Tesla, had started a career in the military only to enter the church shortly after he married. As the Tesla line had always given a son to the church the family expected that Nikola would eventually become a clergyman. His older brother, Dane, had evidenced a brilliant mind, and would bring honour to the family as a scientist or engineer. However, Dane

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# The inventive genius of Nikola Tesla

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died at the age of 12, the result of an accidental fall from a horse.

Nikola had proved to have an equally find mind and a keen insight. Although his inclinations were secular, Milutin Tesla remained adamant that Nikola would enter the church.

His work in school continually astounded his teachers, for he had the ability to do lightning calculations mentally. At one point he received a failing mark in an examination, for it was assumed that he had surely cheated. Only when he demanded another examination from the director of the school, and solved problems far in advance of his years did his mentors accept his astonishing talent.

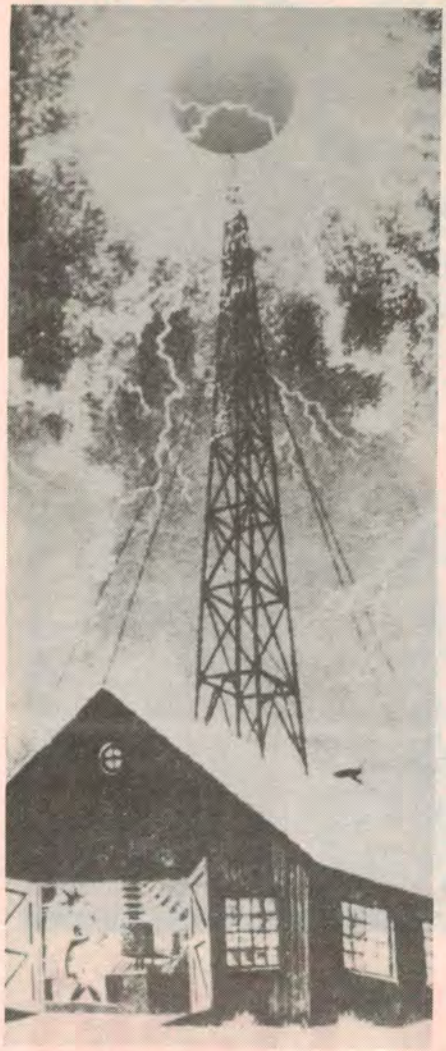
Academic work filled only part of his life. He haunted the woods near his home. It is said that he built a water wheel at a nearby stream when he was only four years old – perhaps foreshadowing his inventive abilities. On seeing a picture of the mighty cascade, he prophesied that he would "someday go to America and harness Niagara Falls."

Another of his childhood inventions was a popgun that fired a ball of wet hemp. These proved so successful that he manufactured and sold a number to his mates. A rash of broken windows ended this foray into business. His attentions were then captured by archery. He went from longbow to crossbows and arbalests of his own design.

At the age of 12, he made an unsuccessful parachute jump from the barn, using an umbrella. He proved the same as Leonardo da Vinci had, several hundred years earlier – the relative strength of materials can let you down rather abruptly. Despite his misadventures he devoured his lessons and when he was 15, continued his academic work at the Higher Real Gymnasium in Karlovac, Croatia.

He completed the four year course in three years. Whilst there, he lived with an aunt and her husband, a retired army officer. His aunt thought his slight frame a sign of delicate health and believed that heavy meals would harm him. Tesla remembered this period as the hungriest of his life and possibly this experience gave him a preference for lavish meals and fine wines in later life.

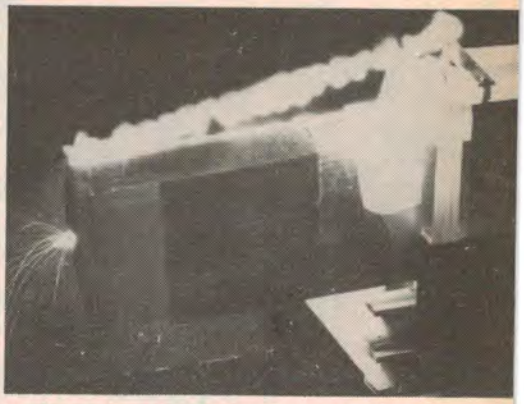
Nikola Tesla loved to take hikes along the snow-covered trails near Karlovac. One day, he began rolling snowballs down a snowy slope, trying to see how large one could get. He succeeded only too well, and watched in horror as an avalanche roared down the moutainside. It diverted itself harmlessly in a field, narrowly missing some farm buildings. The young man was horrified at the near damage he had unwittingly caused – but recognised that a small action by a man could have great influence on natural forces. The thought that the tremendous power of nature could be harnessed and controlled by the relatively small efforts of men became a guiding force in his life.



*In 1899 Tesla began experiments in Colorado on wireless transmission of power, shown in this artist's impression.*

During this period, he observed that lightning strikes preceded torrents of rainfall from the dark cloud masses, and speculated that the lightning itself triggered the rain directly. He would eventually succeed in creating an atmospheric mist artificially. In writing about the electrical control of the atmosphere, he would state: "The time is very near when we shall have the precipitation of the moisture of the atmosphere under complete control. . ."

On his graduation, he received a letter from his father, urging him to take a hunting trip and relax from his three years of effort. Instead, he returned home and found the area in the grip of a cholera epidemic.



*Tesla coils are put to work today in simulating lightning strikes on aircraft.*

Worse than this, he also found that his father still expected him to enter the church. Now, Milutin Tesla knew that if his son did not do that, he would be expected to serve three years in the army. Too, he was concerned at Nikola's precarious health. But Nikola could not understand his father's worries. He only knew that he wanted to continue his technical training. He felt the army would be a waste of his education – and the obligations of the church would leave him no time to unlock nature's secrets. He fell ill.

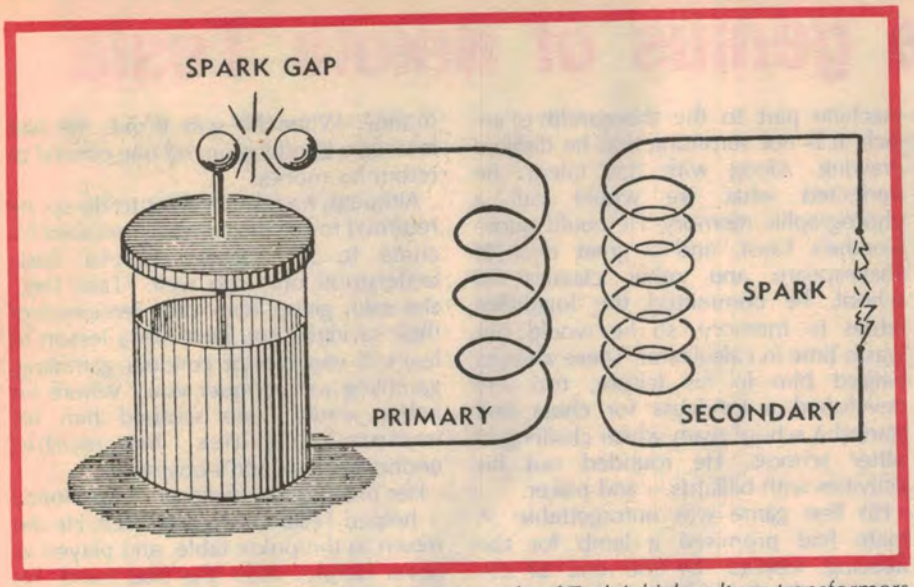
For week after week, one sinking spell led to another. Three years of undernourishment and his present spiritual anguish left him with no will to live. Doctors told the family that they should prepare themselves for his imminent death.

Milutin Tesla faced his own crisis. True, he had pledged Nikola to the church; but if the young man died, the pledge would be unfulfilled. Knowing the answer, he begged his son to tell him what would help him.

"I could get well," Nikola whispered, "if I could study engineering." His father made a solemn promise and in a short time, Nikola began to recover. In later years, he wrote that no magical event had taken place – instead, his mother had mixed a potent but unpleasant medicine so revolting that it forced his recovery.

Milutin Tesla sent Nikola away to the mountains to convalesce for some time. When he returned, the army had declared the young man unfit for military service on medical grounds. Whether the father's influence on family members in the army had anything to do with the decision is not known.

In 1875, Nikola enrolled in the




*A contemporary drawing illustrates the principle of Tesla's high voltage transformers.*

Polytechnic Institute at Graz, Austria. Chafing under all the lost time, he took twice the normal number of subjects, limiting himself to four hours' rest a night. In a year, he returned home with the highest possible marks. Instead of praise, his father reviled him for endangering his health. Years later, Nikola learned that the dean of the technical faculty had written to his father: "Nikola is a star of the first rank, but will kill himself from overwork."

Respecting his father's wishes, he returned to a second year at the Institute, limiting himself to a study of physics, mechanics, and mathematics. When he saw a demonstration of a Gramme dynamo, he remarked that the sparking at the commutator surely was a sign of power loss. His instructor, Professor Poeschl, patiently elaborated on the necessity of using a commutator to provide the useful direct current output.

Tesla responded that, by discarding the inefficient commutator, the inherent alternating current could provide more power. Everyone laughed, for they knew that AC was useless. Possibly, this belief dated back to Faraday's experiments, using a galvanometer. The indicator could only detect steady currents or momentary currents which reversed very slowly. It would remain perfectly quiescent (in the words of a 19th century academic) whilst to-and-fro currents of tremendous energy were circulating through the circuit to which it was connected.

Yet, Professor Poeschl took Tesla's intellect seriously enough to devote the next lecture to the young man's speculations on alternating currents. He concluded, however: "Mr Tesla may accomplish great things, but he certainly never will do this."

Popular wisdom went so far as to state that "the positive and negative cancel one another." Certainly, efforts by some inventors had not succeeded in developing a workable AC motor.

Tesla' conjectures were put in the same category as perpetual motion machines. Even though Tesla pointed out that AC would drive a passive load, such as a street arc lamp, and thus was doing work, no one accepted any further ideas

*continued on page 26*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# The inventive genius of Nikola Tesla

*Continued from page 25*

of utility. Though Tesla bowed to the authority of his professor, the concept tantalised him. He imagined plan after plan and discarded them.

From his earliest years, Tesla had possessed an amazing gift of visualisation. As a child, anything he imagined seemed to appear before him, solid and as real as any object in the material world. It came as quite a shock to the little boy to discover that other people could not see his images. The unique talent had worried him and he'd tried to suppress it. Later, he discovered that he could put it to good use, although he no longer tried to get other people to see his projections.

Later autobiographical writings reveal that he perfected his engineering models in his mind. He claimed that "they were so real that he could see signs of wear, and in the case of rotating machinery, could actually tell whether or not it might be out of balance."

With a mind that could visualise a machine part to the thousandth-of-an-inch, it is not surprising that he disliked drawing. Along with this talent, he perfected what we would call a photographic memory. He could quote Goethe's Faust, and a great deal of Shakespeare and other classics. In school, he committed the logarithm tables to memory, so he would not waste time in calculation. These abilities helped him in his leisure, too. He developed a fondness for chess and started a school team which challenged other schools. He rounded out his activities with billiards – and poker.

His first game was unforgettable. A mate had promised a lamb for the fleecing. Instead, by the end of the evening, the lamb had won all – and then confounded everyone by returning, to the cent, what each had lost.

Tesla looked on cards simply as a relaxation. Time after time, he returned to the tables. One night, for some reason, his luck or his ability let him down. He lost hand after hand, and ended up betting the next term's tuition money. When he was broke, he had learned a good lesson: no one offered to return his money.

Although he felt reluctant to do so, he returned to him home and confessed his crime to his mother. Djouka Tesla understood only too well. "Take this," she said, giving him what remained of their savings. "You have yet a lesson to learn. If you cannot conquer gambling, gambling will conquer you." Where his father would have scorned him for immoral activities, his mother understood her son's obsession.

Her practical psychology – and money – helped Tesla to know himself. He did return to the poker table, and played as never before. After the final hand, his "friends" expected their losses to be returned, as usual. This time, Tesla kept the lot. He had won back what he had lost. The money his mother had advanced him was returned gratefully and he made a solemn oath never to play cards again.

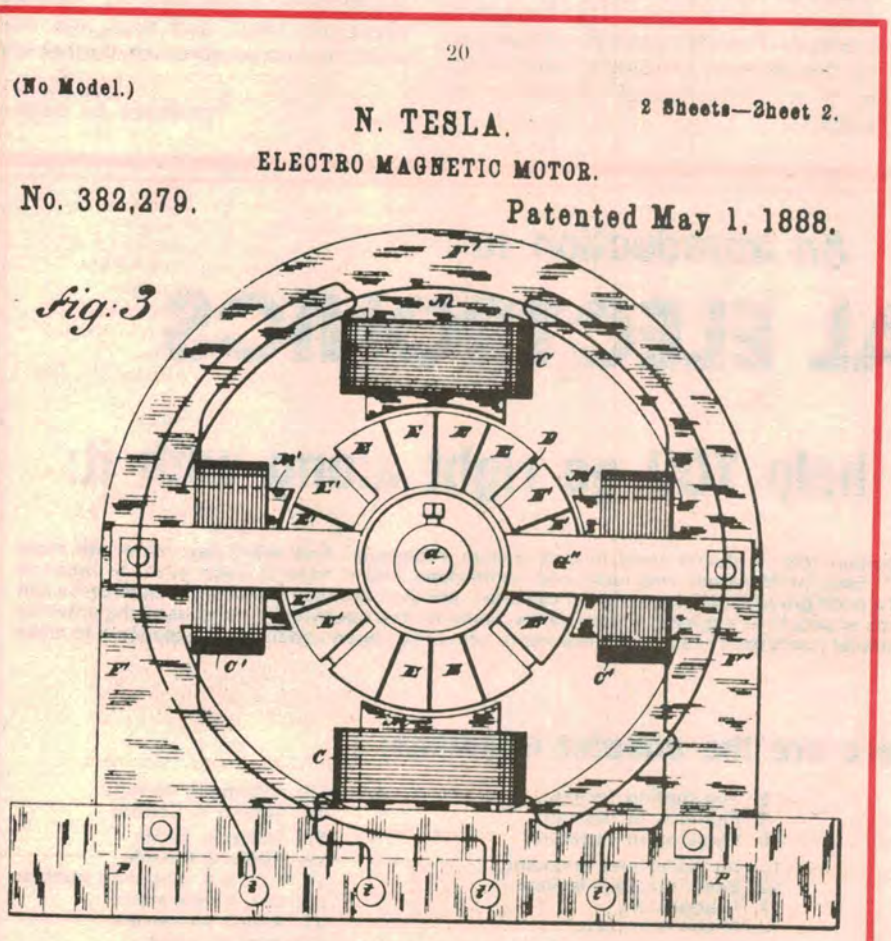
A little later, he completed his studies at Graz and took a job at a tool-and-die works in Maribor which manufactured electrical equipment. The money he saved enabled him to take a further year's study at the Unversity of Prague.

In 1881, he travelled to Budapest, in hopes of getting a position at the new telephone central office being built. His excellent academic credentials opened no doors for him. Instead, he was offered a lowly job at the Hungarian Government Telegraph Office. Forty years later, he wrote that it was "at a salary I deem it my privilege not to disclose."

"By an irony of fate, my first employment was as a draughtsman. I hated drawing; it was for me the very worst of annoyances."

Yet, Nikola Tesla's ability made itself evident; soon, he was promoted to more responsible work and finally made chief electrician to the telephone company. At the age of 25, he stood as engineer-in-charge of an entire system. His arduous schedule did include five hours of rest a night, two of them in sleep ... He relaxed for three hours keeping up with the technical journals.

At this time, he invented what might be thought of as a "speakerphone," a type of loudspeaker device by which a number of people could listen to a telephone conversation. Tesla never bothered to patent this invention, although the telephone company did utilize it. Thirty years later, he remarked that it compared favourably with the current loudspeakers.



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(No Model.)

N. TESLA.

2 Sheets—Sheet 2.

ELECTRO MAGNETIC MOTOR.

No. 382,279. Patented May 1, 1888.

Fig: 3

*The principle of operation of three-phase AC motors is unchanged since Tesla's 1888 patent. Simultaneously he was issued patents for an AC generator, transformer and power distribution system.*

*Next issue: Tesla meets Edison.*