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MUSEO ITALIANO DELLA GHISA
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ELECTRIC LIGHTING: FROM ARC LAMP TO CARBON-FIBRE FILAMENT LAMP

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At the beginning of the 19th century, the only available means to produce electricity were the "friction machines" - electrostatic equipment able to generate electric discharges which, however, could produce sizeable currents only for a few seconds. Things radically changed when **Volta invented the electrical battery**, which, despite its low current and voltage, allowed more constant currents to be produced. After these inventions were introduced, electrical phenomena were no longer simply a topic of small talk. Within a few decades, the sudden availability of electrical current led to the advent of a new industry, which not only revolutionised all aspects of our daily lives, but also changed production processes.

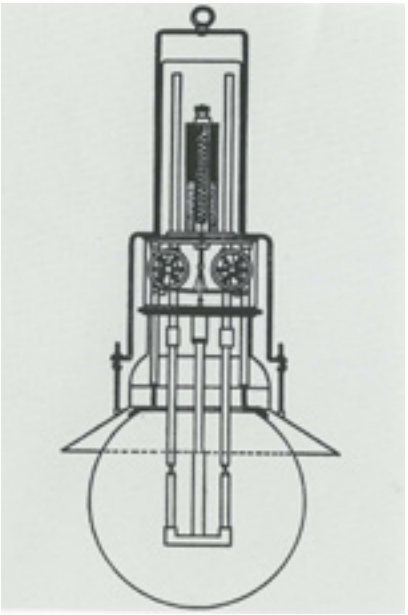
After Volta's equipment was developed - the first rudimentary current generator - the capability to produce light from electricity was almost immediate. As early as 1802, in fact, the English chemist Humphry Davy studied the spark that was produced between the poles of Volta's battery. By using a battery made up of 2000 cells (housed in a basement), he had already discovered that, if instead of the metal filaments which caused the circuits to close, well calcined carbon elements were used, the spark would look more intense and brighter. This **electric arc**, named "voltaic arc", became the subject of a large number of studies, which, following the first successful manufacture of arc lamps, led to the tentative launch of electrical lighting on

Volta generates more constant electric currents and shows his discovery to Napoleon (1802)

Volta's battery is the first, rudimental generator of direct current

a commercial scale. This attempt was doomed to fail as the cost of maintaining such cumbersome cells of batteries required to produce current was far too high.

The **first commercially available arc lamp** was developed by Staite in 1853, whilst the arc lamp developed by Crompton, with two arcs and a simpler regulator, ensured better efficiency. The arc lamp was basically made up of two electrodes, normally made of carbon (graphite), crossed by current, both direct and alternating. The arc was created by two electrodes initially in contact and then drawn apart. The light produced was particularly bright and white, very close to the solar spectrum, although quite unstable and rich in ultraviolet rays.
These features made it ideal for lighthouses and large areas such as industrial buildings. It was used for public lighting, both fitted to moulded cast iron poles and brackets and to the middle of the road by suspending them on a taut rope. The arc lamp became very popular between 1880 and 1920 and played a major role in the development of the electrical industry. That was the time when the new technology and the gas technology often led to heated confrontations, debates and litigations, particularly amongst the pioneers of electricity and the gas companies, which did not want to lose their monopoly.
Another leading figure of the time showed an interest in the arc lamp - Nikola Tesla, a Serbian electrical engineer, a visionary and tireless researcher, whose inventions still remain milestones of the "electrical revolution" that reached its peak at the end of the 19th century.



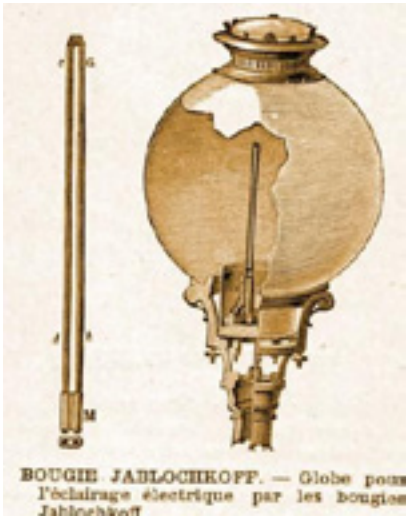
Crompton creates a more efficient arc lamp than the one developed by Staite in 1873: it features two arcs and one simplified regulation mechanism

1799 VOLTA | **1802** DAVY | **1853** STEITE | **1878** EDISON | **1880** CRUTO

Meanwhile, a partial definition of the "arc" was reached when, in the 1870s, the Gramme machine was developed. It was a sort of dynamo made with strong and long lasting mechanical components, which was the first electrical generator able to operate continually without the risk of overheating. Coupled with steam machines, these dynamos were the essential components for the **first arc-lighting systems**. The Gramme's Paris based factory was in fact the very first building to be illuminated by using this system.

When in 1876 the Russian telegraph operator Jablochkoff finally developed a lamp supplied with alternating current, and in the following year the Gare de Lyon in Paris was lit by using 12 lamps connected in series to a single generator, it became apparent that electric lighting would become the system of the future. A source of bright, strong and relatively constant light had been found, although some substantial drawbacks remained, such as the need to frequently replace the arc producing electrodes and the difficulty of ensuring the same intensity of light to multiple lamps connected in series. Furthermore, the problem of lighting smaller places, where the arc lamp was not widely used as they were too powerful still remained unsolved, whilst gas was increasingly felt as a potential cause of fires and of toxicity in the event of leaks.

GARE DE LYON IN PARIS WAS LIT BY 12 LAMPS CONNECTED IN SERIES TO A SINGLE GENERATOR (1876)


BOUGIE JABLOCHKOFF. — Globe pour l'éclairage électrique par les bougies Jablochkoff

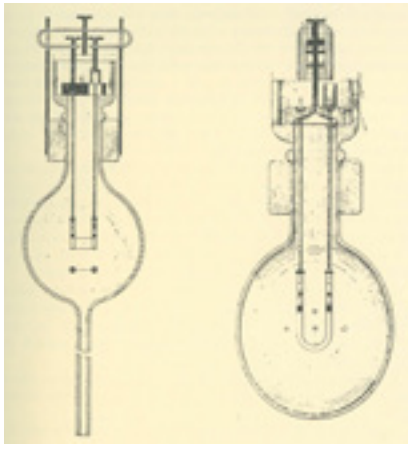
The introduction of the lamp designed by the Russian Jablochkoff (1876) leads to the widespread use of electric lighting in public areas: roads, bridges, railway stations.

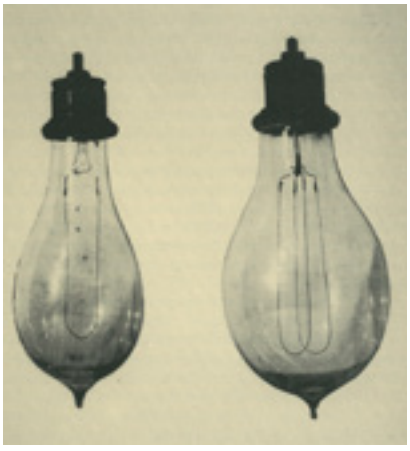
To solve the problem a specific study on how to apply carbon foils inside the lamps needed to be carried out (the physical phenomenon called incandescence, when an object heated to high temperatures emits light; the terms derives from the Latin word candescere, i.e. "becoming white").
On the May 24th, 1879 the Piedmont born Alessandro Cruto, a contemporary of the American Thomas Edison and his competitor in inventing the electrical lamp, went to the Industrial Museum in Turin to attend a conference held by professor Ferraris on lighting with incandescent lamps. Edison was able to develop the first filament lamp which, however, was very inefficient as the filament had a very short life (only a few hours). Ferraris openly expressed his concern that the electric incandescent lamp had little or no potential application in lighting cities because, although the theoretical solution to the problem has been found some thirty years

earlier, a **filament able to withstand the incandescence** temperatures was yet to be found. Cruto, a self-taught genius and extremely talented chemist and physicist, took on board Ferraris' concerns and, from then on, worked relentlessly to reach a single objective: developing suitable carbon filaments in his "laboratory" based in Piossasco. As he explained himself, the filaments had to be made of pure carbon, have a diameter of five hundredth of a millimetre, be identical, stretchy yet not too fragile, electrically resistant and able to emit light. On March, 5th 1880, by using the electrical current produced by a Bunsen cell battery, he lit his very first incandescent lamp in the department of Physics of Turin university and, in September of the same year, he developed a bulb that was named after him, which proved to be better than all the previously developed bulbs, including Edison's bulb.

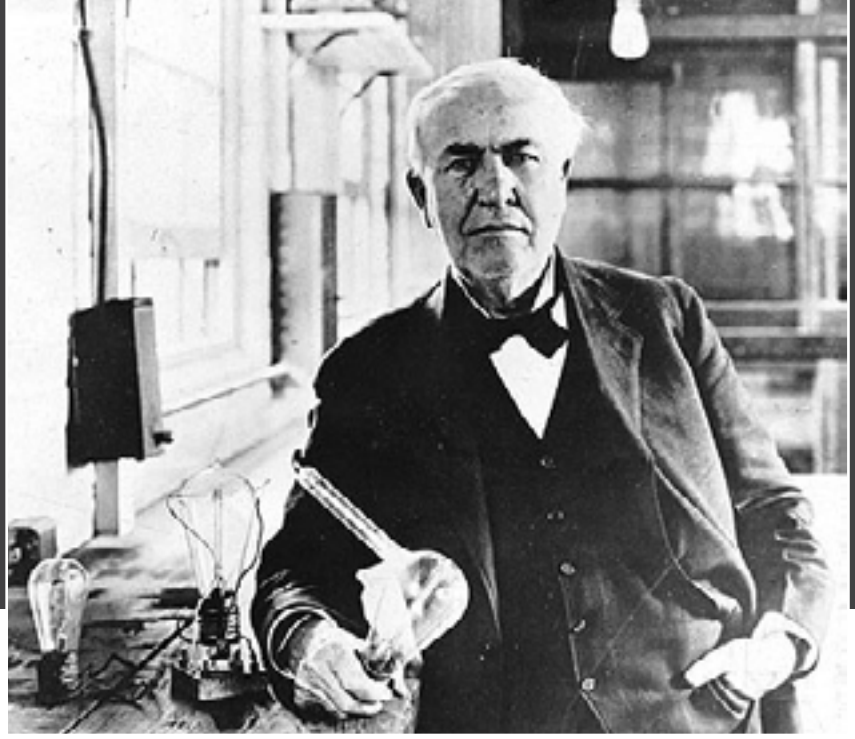
The lamp needed to be introduced and made commercially available; however, Cruto's lack of funding experienced throughout his research activities became a major obstacle although, towards the end of 1881, an opportunity presented itself. At the time Turin based Bardelli opticians were testing Swan lamps with a filament made of chemically carbonised cotton threads sent from London; Cruto suggested a comparison test. The outcome was so successful for Cruto that he was able to quickly find four people willing to invest in his project which led, in 1882, to the set up of the Company A. Cruto e Comp., based in Piossasco.

Cruto works incessantly in his Piossasco laboratory to achieve a single objective: producing carbon filaments able to withstand incandescence.





On March 5th 1880 Cruto lights up the first incandescence lamp, which proves to be superior to all previous lamps, including Edison's.



Edison: the first entrepreneur to apply the principle of mass production to an invention process

The work to be carried out seemed very daunting: in addition to the production equipment, an array of other components needed to be manufactured, such as lamp holders, switches and isolators for outdoor systems; in other words, an actual industry, where all the required components could be manufactured including, of course, the machinery (dynamos, alternators) required to produce energy.

For the filament, Cruto decided to deposit some carbon over a very fine platinum wire - previously crossed by an electric current able to make it extremely hot - in a hydrogen-filled atmosphere (ethylene). At this point he was able to produce a thickness of suitably sized and shaped carbon to generate an electrical resistance then, by increasing the electric current, he ensured that the platinum wire evaporated and its coating acted as a filament (of very pure carbon).

Instead of featuring impurities and random sizes, which inevitably occurred when natural fibres were used, **Cruto's graphite was pure and could be produced in the desired sizes**. Cruto's superiority was acknowledged in 1893 by the tests carried out in the Department of Physics of Zurich Polytechnic under the supervision of prof. Weber, Einstein's teacher. Meanwhile, in 1885 the first factory producing Cruto's designed electrical lamp was opened in Alpignano, near Turin.

At the same time, the brilliant physicist Edison who, unlike Cruto, was backed by massive funding, manufactured his lamps featuring a filament obtained by chemically carbonising natural fibres, specially cotton; his objective was to make a carbon filament by using natural products (this is why the product developed by Cruto could quite rightly be acknowledged as the first entirely artificial filament). Edison's extensive research activity was carried out in Menlo Park laboratories, California, where all technological issues were tackled; he was able to create a lighting system where all the components, from the generator to the distribution network, to the incandescent lamps, were designed to make up an assembly of compatible equipment, in order to set up a new business venture: the centrally controlled production of electricity for lighting purposes. Edison was therefore the first entrepreneur able to apply the principles of mass production to the invention process, which is what earned him his fame.

One more issue was yet to be solved: how to "split the current" so that all the lamps connected to a single generator could be supplied with the same current, regardless of how far they were located, and could not be affected by switching on or off other lamps of the circuit. Therefore, the new system needed to be efficient,

ITALY PLAYED A MAJOR ROLE IN THE DEVELOPMENT OF THE LAMP AND IN BUILDING THE FIRST POWER STATIONS

as well as **commercially viable and competitive when compared to gas lighting**. To achieve this, it was crucial to build power stations in areas with a high number of potential users: this was one of the main objectives all large cities focused on, in order to ensure that electric lighting could finally be distributed without any more obstacles.

In Italy, the thermoelectric station of via Santa Radegonda, Milan, which entered service in June 1883, is generally regarded as the very first power station developed in Europe, although British literature attributes this achievement to the London based Halborn Viaduct power station, which entered service a few months earlier; therefore, the Milan based factory should be more correctly regarded as the first power station of continental Europe. The commissioning of the European power stations was just preceded by that of the New York based Pearl Street power station. However, national feelings aside, what is interesting is that the applications of electricity in the city of Milan were achieved simultaneously to those in the USA, and two years earlier than those in Berlin. Therefore, Italy played a major role not only in the development of the electric lamp, but in building the first power stations used to produce this new type of energy.

Nights in Milan are lit up by the same incandescent lamps used to illuminate for the first time the entrance of La Scala Theatre on December 26th 1883.

LA GAZZETTA PIEMONTESE
TORINO, 2 OTTOBRE 1882

An article was featured in the **Gazzetta Piemontese** *(Piedmont Gazette) of October 2nd 1882.*
The Gazzetta Piemontese daily newspaper was published in Turin from 1867 to 1894; the following year it changed its name to **La Stampa**, *which is still one of the top Italian daily newspapers.*

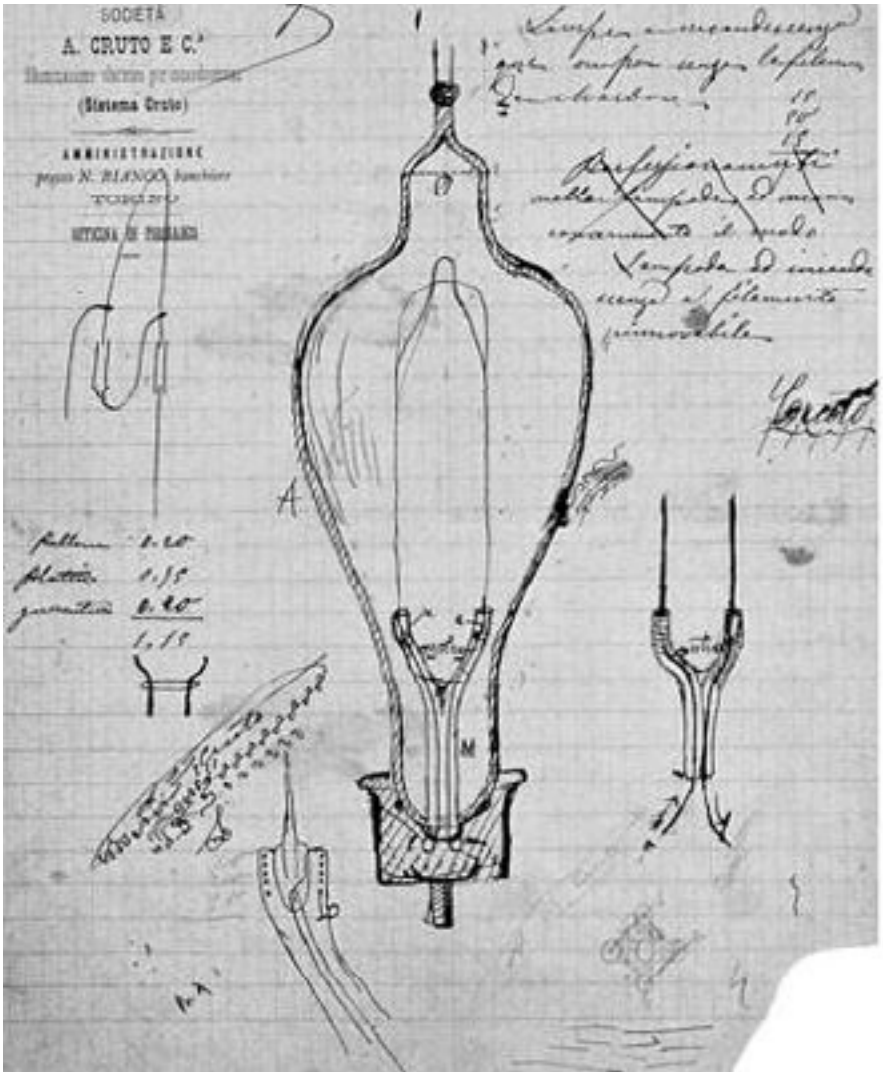
Abstract

The article, entitled The Italian Edison is dedicated to Alessandro Cruto, who was born in Piossasco, a small town near Turin, Piedmont. Because of his social status, he was doomed to be a labourer but, from a very early age, showed a keen interest in physics. Without having any resource, he studied in total solitude for over ten years then, with the financial support of a few wealthy people, was finally able to announce his discovery to a small number of close friends. This discovery solved of the most important physical problems of that era, which was unsuccessfully tackled to Edison himself, i.e. to deposit pure carbon (which is a light substance with a dazzling bright shine) over an object by means of an electrical discharge. Cruto then transferred this procedure to platinum wires enclosed in a glass lamp where an internal barometric vacuum was crated to produce his own electric bulb.

The scientist also designed a special, flexible connection to be used to suspend his incandescent lamp.

The daily newspaper boasts being one of the very few to attend Cruto's first testing of his lamps. "The light produced can be split, just light gas lighting, it is constant, clear, and far cheaper than other electric lights; it is, in other words, a true invention. Despite his huge success, Cruto never lost his modesty, but we realise we were right in predicting that his invention shown to the public would have been deservedly acclaimed."

Alessandro Cruto



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