Università degli Studi di Pavia
Sistema Museale di Ateneo

Museo della Tecnica Elettrica / *Museum of Electrical Technology*

Un anno al Museo 2013
Museum Year 2013

a cura di Antonio Savini
edited by Antonio Savini

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Presentazione

Riflessioni sul passato e sul futuro, che peraltro sono al cuore della missione del Museo, hanno caratterizzato le attività del Museo durante tutto l'anno.

A marzo il prof. Gianmarco Veruggio ha tenuto la Conferenza annuale proprio su passato e futuro della robotica, una disciplina dal breve passato e tutta orientata verso il futuro. Le operazioni di ogni giorno, praticamente in tutti i campi, stanno diventando sempre più automatizzate mentre all'orizzonte appare una domanda etica: in quale misura i robot possono sostituire l'uomo?

Ritornando al passato, argomento del seminario internazionale tenutosi a settembre sono stati i primi generatori negli impianti elettrici delle origini destinati all'illuminazione elettrica.

Alla fine dello stesso mese il Museo ha ricevuto, con una cerimonia ufficiale, reliquie di storia e di storia della tecnologia a Pavia.

Durante l'anno è continuata la collaborazione con il Laboratorio di elettronica dell'Università che attraverso l'iniziativa "Ondivaghiamo" ha prodotto esperimenti sulle onde, di richiamo soprattutto per i gruppi scolastici. Questi ultimi hanno contribuito a portare il numero dei visitatori del Museo a circa 4.000 nell'anno.

Preface

Reflections on past and future, which belong to the core mission of the Museum, have characterized the activities of the Museum throughout the year.

In March prof. Gianmarco Veruggio delivered the Annual Lecture on past and future of robotics, a discipline with short past and a strong orientation towards future. Everyday operations practically in all fields are increasingly becoming automated and an ethical question appears at the horizon: to what extent can robots replace humans?

Turning to the past, early electric generators supplying the first power systems consisting of electric lamps were the subject of an international seminar held in September. Later in the month the Museum officially received the donation of relics of history and history of technology in Pavia.

During the year the continued cooperation with the Laboratory of electronics of the University has produced experiments of waves attended and appreciated particularly by school groups. These groups have substantially contributed to increase the number of visitors of the Museum to about 4000 in the year.

Il Centro Interdipartimentale di Ricerca per la Storia della Tecnica Elettrica (CIRSTE)

The Research Centre for the History of Electrical Technology

Eventi dell’anno al Museo della Tecnica Elettrica

Events in the Museum

2013

Museum Day e Annual Lecture

Robotica tra passato e futuro / *The past and future of robotics*
Gianmarco Veruggio, Scuola di Robotica, Genova
2 marzo 2013

Lectures and demonstrations
Ondivaghiamo – esperimenti sulle onde
Waves – Learning about waves by experiments
gennaio-febbraio 2013 – giugno-dicembre 2013

International Seminar
Early electric generators and the first electric lights
6 settembre 2013

Special event
Memorie di storia Pavese / Memories of local history in Pavia
30 settembre 2013

Sabato 2 marzo 2013

Museum Day 2013

Il 2 marzo 2013 il Museo della Tecnica Elettrica di Pavia ha festeggiato il sesto anniversario di apertura al pubblico.

Momento centrale del Museum Day 2013 è stata la Conferenza Annuale tenuta dal prof. Gianmarco Veruggio, della Scuola di Robotica di Genova. La robotica persegue uno dei sogni più alti dell'uomo, quello di costruire macchine operatrici dotate di intelligenza artificiale. Le applicazioni, rese possibili dai progressi di scienza e tecnologia, si sono allargate enormemente dal mondo delle fabbriche, alle sale operatorie, alle avventure spaziali e al mondo dei giochi.

Dopo la Conferenza è stato inaugurato l'allestimento dell'esperimento di conversione di energia meccanica in energia elettrica con bici-generatori. Grandi e piccoli sono stati invitati a salire su biciclette, a pedalare e a misurare la potenza elettrica prodotta.

On Saturday 2 March 2013 the Museum celebrated the sixth anniversary of its opening.

The core event of Museum Day 2013 was the Annual Lecture delivered by Prof. Gianmarco Veruggio, Scuola di Robotica, Genova. Robotics pursues one of the highest dreams of humans, that is to build working machines having artificial intelligence. The applications of robotics, made possible by the progress of science and technology, have spread widely from the world of factories to operating theatres, to space programmes and to the world of games.

After the Lecture the display of an experiment showing the conversion of mechanical power into electric power by "bicycle-generators" has been opened. Adults and children have been invited to ride on bikes, to produce electric power by pedalling and to measure the power produced.


Museo della Tecnica Elettrica - Unipv
tra passato e futuro


"L'UOMO, L'ENERGIA, LA VITA"


"L'UOMO, L'ENERGIA, LA VITA"

Gennaio – febbraio; ottobre – dicembre 2013

Ondivaghiamo: esperimenti sulle onde
Learning about waves by experiments

"Ondivaghiamo" è un progetto che prevede lezioni sperimentali interattive nelle quali si illustrano le caratteristiche delle onde e i diversi aspetti dell'esperienza quotidiana che si possono ricondurre a fenomeni ondulatori, avvalendosi di alcuni esperimenti appositamente progettati e coinvolgendo il pubblico nell'esecuzione degli stessi. Le lezioni, con diverso livello di approfondimento, sono rivolte alle scuole primarie e secondarie e al pubblico generico.

Il progetto per le scuole secondarie superiori si compone di due moduli, uno dedicato alle onde meccaniche e uno alle onde elettromagnetiche, mentre quello per le altre scuole e per il pubblico generico è ridotto ad un solo modulo.

Le lezioni di ciascun modulo durano circa un'ora e mezza.

"Ondivaghiamo" is a project consisting of interactive experimental lectures showing the characteristics of waves in their various aspects of everyday life. Experiments are especially designed for the audience which is expected to participate in them. The intended audience is pupils of primary and secondary schools and also the general public.

A single module is suggested for the general public and primary schools, while two modules, one devoted to mechanical waves and the other to electromagnetic waves, are offered to upper secondary schools.

Each module takes about one hour and a half.

6 settembre 2013

Early electric generators and the first electric lights

International Seminar

The early development of electrical technology may be considered in three stages. After the basic principle of the generator was demonstrated, practical generators were developed and these provided power for the first electric lights.

Programme

The first electric light
Sàndor Jeszenszky

The first practical generators had many applications, including electrochemistry and even early motors, but the most spectacular was the arc lamp, which required a regulating mechanism.

A new look of the Pixii machine – the first electric generator
Brian Bowers

In 1831 Faraday showed that a pulse of electricity was produced when a magnet moved near a coil of wire. The following year Pixii mechanized the arrangement, producing the first generator, which Ampère said would become as important as the frictional electric machine.

Early electric generators in the Deutsches Museum
Friedrich Heilbronner

The first practical generators were the Gramme dynamo with the ring armature and the Siemens dynamo with the drum armature.

The first electric light

Sándor Jeszenszky, Hungarian Museum of Electrotechnics, Budapest

Abstract

The electric light was demonstrated by H. Davy in 1812. The brilliant light of arc lamps was a challenge for oil lamps. Early arc lamps were hand-controlled; their regular operation later was made possible by the self-acting control of carbon rods.

Initially arc lamps were supplied by batteries, later by magneto-generators and after 1885 by AC generators. Arc lamps used to be series-connected by means of series regulators or parallel-connected by parallel controllers. They remained in operation for electric lighting up to the 1940s.

1. The first steps in electric lighting

The arc lamp was the first spectacular application of electricity after the discovery of the battery producing a continuous electric current. The source of light was an arc discharge between two carbon rods. The temperature of the positive electrode was about 4000 centigrade and it gave a nearly continuous spectrum from infrared up to ultra-violet rays.

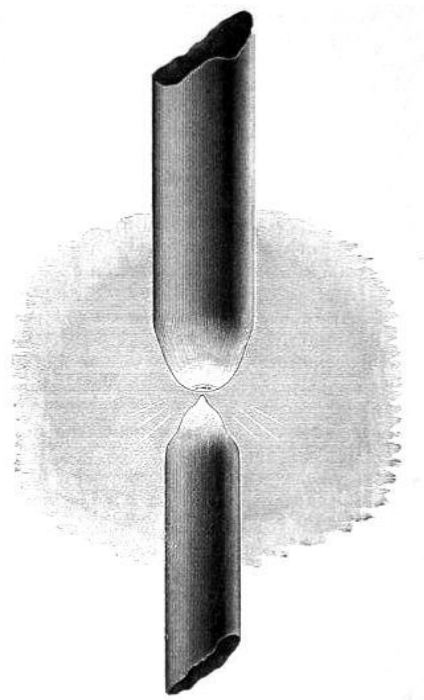


Fig. 1. Electric arc between carbon rods

Humphry Davy (1778 – 1829) demonstrated the electric light in the Royal Institution in 1812; it was a 3 inch long arc discharge between two charcoal rods, but the rods burnt down and the primitive battery became exhausted in a few minutes.

The brilliant light of the arc, like the daylight or the light of thousands of candles, was a fantastic sensation in the age of the oil lamps. It was said that the electric light could project the shadow of a candle flame onto a wall.

The practical application of the arc lamps began only in the 1840s, when the powerful batteries of Bunsen and Grove and the solid gas-carbon rods made it possible to operate for one or two hours. The gas-carbon came from the retorts of the urban gas works, so it was a link between the gas- and electric lighting. The arc lamp was a wonderful sight on evening celebrations, like the fireworks in the baroque age and for special light effects in theatres.

Initially arc lamps were controlled by hand because they required continuous readjustment by an operator (Fig. 2).

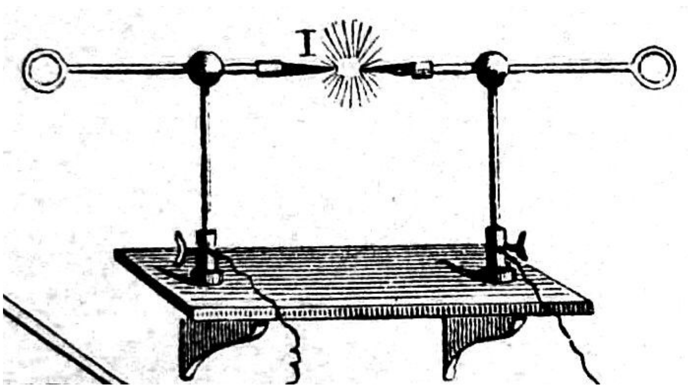


Fig. 2. Manually operated arc lamp

The operator had to touch the rods together then draw them back 2-3 mm in order to start the arc discharge and then to readjust the rods as they burnt down during the operation [1].

2. From the manual control to the self acting arc lamps

The self-acting control of the rods made possible the general application of the arc lamp. The control had to work in two directions, first bringing the carbons together and then drawing them in response to the current.

In the lamp of Archereau a counterweight drew the carbon rods together, then the rods closed the circuit and the current drew them back few millimetres by a solenoid coil and stabilized the arc (Fig. 3). The counterweight and the attractive force of the current coil were in equilibrium.

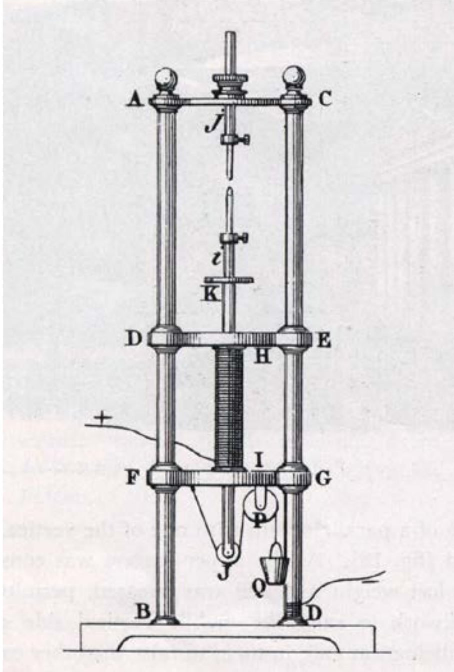


Fig. 3. Arc lamp of Archereau

It was the first self-acting regulator in electrical engineering. The technical term “regulator” meant explicitly an arc lamp in the middle of the 19th century. [2]

In modern technical terms it was a proportional (P-type) negative feedback current control. Its reference signal was the weight of the balance, its feedback signal was the attractive force of the electromagnet and the current of the arc was the controlled value. It was a so called series regulator, because the coil was connected in series with the arc [3] (Fig. 4).

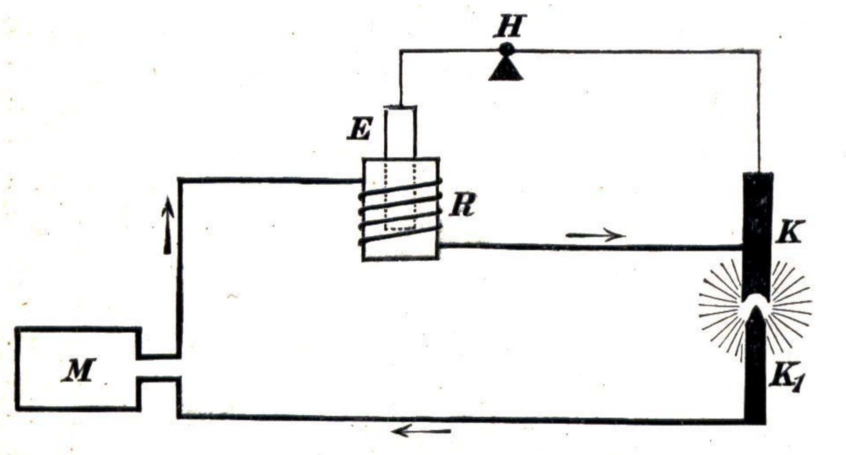


Fig. 4. Series regulator

3. Generators and regulators

In the 1850s more and more lamps were in operation, mostly in lighthouses and harbours, supplied no more by batteries but by big magneto-generators. They were giant machines, but their power was poor, barely enough to supply a single lamp. Each lamp had its own generator. The reason for the low power was the weak magnetic field of the usual permanent horseshoe magnets.

There were 336 horseshoe magnets in the Malderen-Nollet generator (Fig. 5); the mass of the machine was 3000 kg, but its power was no more than 2-3 kW. [4]

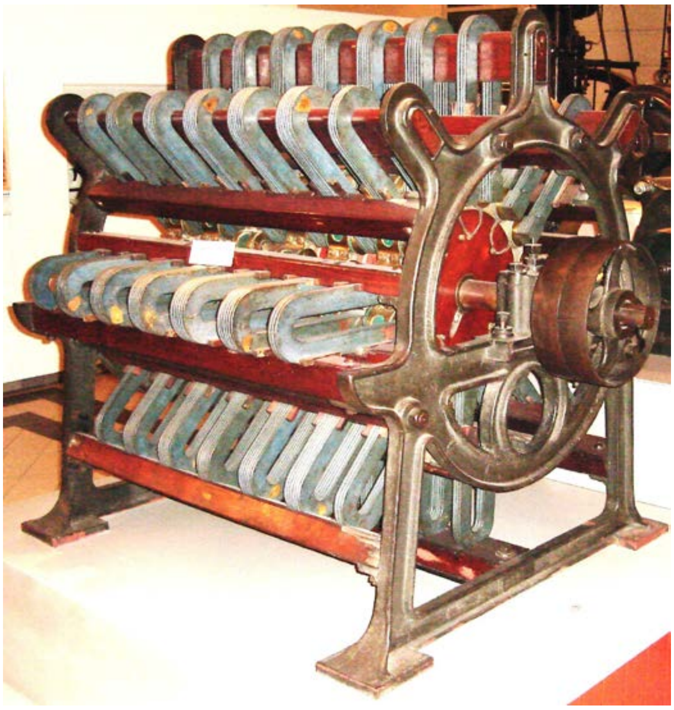


Fig. 5. Magneto generator of Nollet (Technisches Museum Wien)

This situation changed after the invention of the self-excited dynamo-electric generators, excited by powerful electromagnets instead of the traditional permanent horseshoe magnets. The electromagnets were supplied by the generator itself. The mass (and price) of the Siemens and Gramme dynamos was only a tenth or less than that of the magneto-generators. It helped the wide-spread application of the arc lamps. [5]

In Germany the arc lamp of Friedrich von Hefner-Alteneck (1845 – 1904), chief engineer of the firm Siemens, was successful (Fig. 6), (Fig. 7).

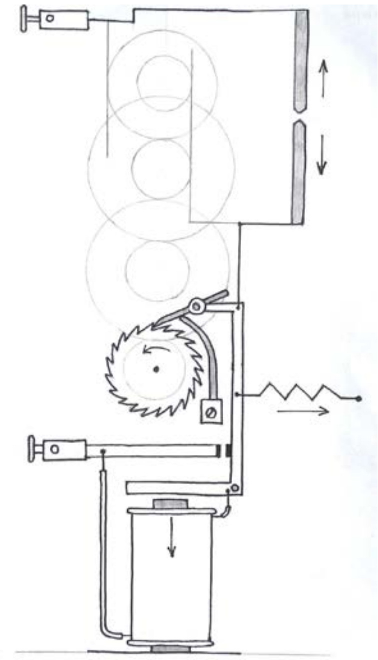


Fig. 6. Diagram of operation of the Hefner-Alteneck series regulator

Fig. 7. Hefner-Alteneck lamp in operation

The weight of the upper carbon rod holder drew the rods together and a current coil drew them back not instantly but step by step by means of a ratchet mechanism, like a modern step-motor. If the current was too strong, the electromagnet attracted the armature and the rachet made a step, but a contact short-circuited the coil at the same time, so the spring of the armature retracted it back. If the current was still too strong, the process has been repeated up to the required value. It operated like an electric bell. It was an integrating function. Using the modern technical term it was a PI-type proportional-integrating controller. [6]

The power of the dynamos of the 1870s reached 10-20 kW, theoretically enough for a dozen lamps, but the so called „distribution of the light" was not yet solved. The „one dynamo, one lamp" units were usual. Ludwig II., King of Bavaria, built a „Venus grotto" in his Linderhof Castle as a scene for Richard Wagner's Opera "Tannhäuser" with electric lighting supplied by Gramme dynamos (Fig. 8), (Fig. 9).

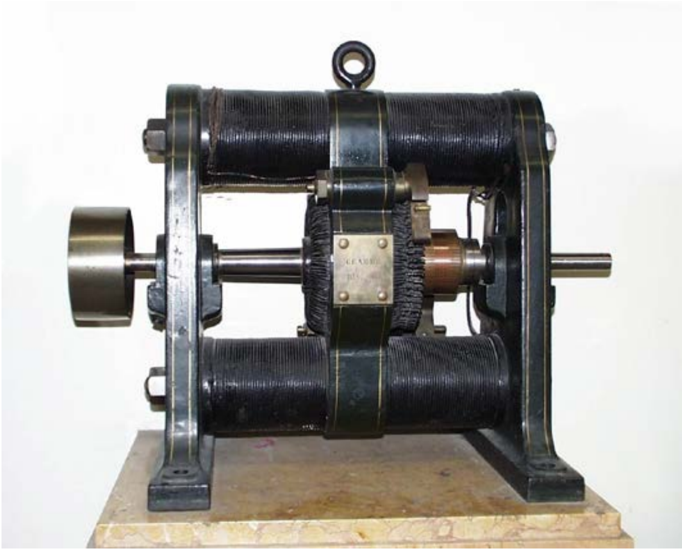


Fig. 8. Gramme dynamo from the Linderhof Castle (Deutsches Museum, Munich)

25 dynamos supplied the 25 arc lamps, spot lights with colour filters. But only a King could afford such a solution.

Fig. 9. Electric lighting in the Venus grotto

4. Distribution of light

Actually the problem was not the distribution of the light, but the equal distribution of the current between the lamps. A simple solution was the series connection of the lamps (Fig. 10).

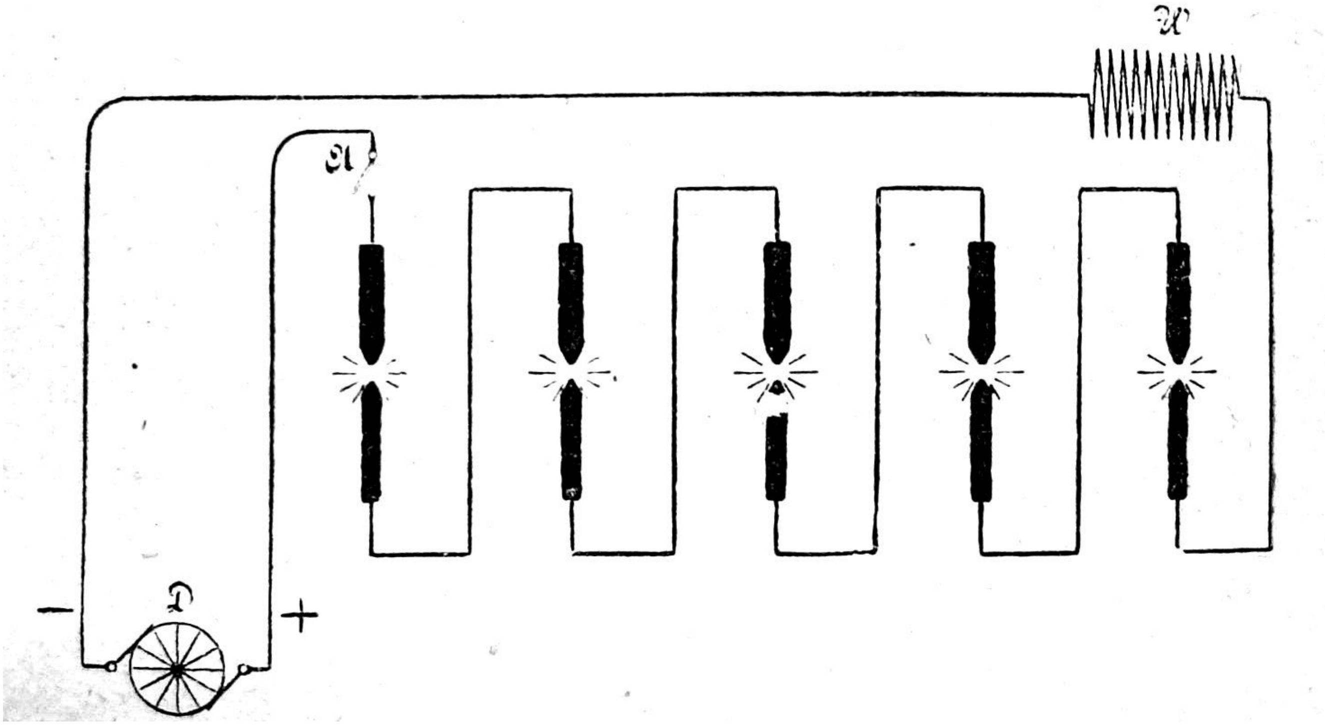


Fig. 10. Series connected arc lamps

In this case the current of all lamps was the same, the regulators of the lamps had to distribute equally not the current, but the voltage between the lamps. It could be solved easier than the distribution of the current. The voltage regulator operated in the opposite direction than the current regulator. It was a parallel regulator, the coil of the electromagnet was not in series with the arc but connected in parallel to it (Fig. 11). It was a voltage coil. It drew the carbon rods not back, but together. When the rods burnt down and the arc and its voltage increased, then the electromagnet drew the rods together.

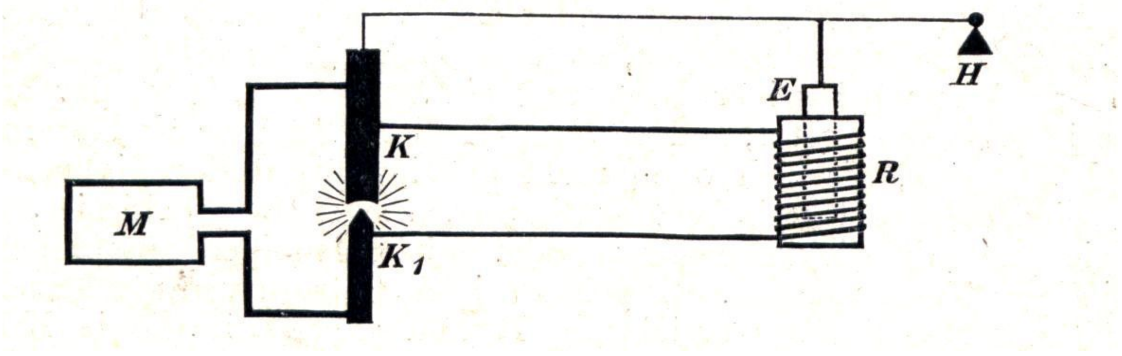


Fig. 11. Parallel regulator

Ten or even twenty lamps could be supplied by one dynamo. But what kind of problem prevented the lamps being connected in parallel, like the incandescent lamps? The incandescent lamp is an ohmic resistance, whilst the electric arc is a non-linear circuit element. After striking the arc its current increases rapidly, up to a short-circuit. It must be limited by a series impedance. In case of the „one generator – one lamp" units the internal resistance of the low power generators was enough for the single lamp, but it couldn't distribute the current equally between more lamps.

Individual resistances were connected in series with each lamp, just as nowadays reactances or electronic adaptors are used with discharge lamps and fluorescent tubes (Fig. 12).

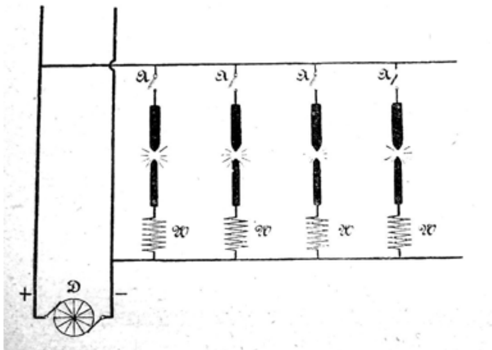


Fig. 12. Parallel connected arc lamps with individual series resistances

In the 1880s many power plants and mains working at 110-120V DC were built, mostly for the incandescent lamps. This voltage was too high for one arc lamp, because its voltage was 35-40V. Therefore the lamps were operated in mixed circuit with two or three lamps in series and several such groups in parallel. It made possible the differential lamp of Hefner-Alteneck.

The differential lamp combined the series regulator with the parallel controller (Fig. 13). There were both current and voltage coils, but the forces of the two electromagnets were in opposite directions. In case of equilibrium the two forces were in balance, the ratio of voltage and current was constant, but it was the resistance of the arc. This regulator controlled neither the current, nor the voltage, but the resistance of the arc. The differential lamps could be switched serial or parallel or in mixed groups.

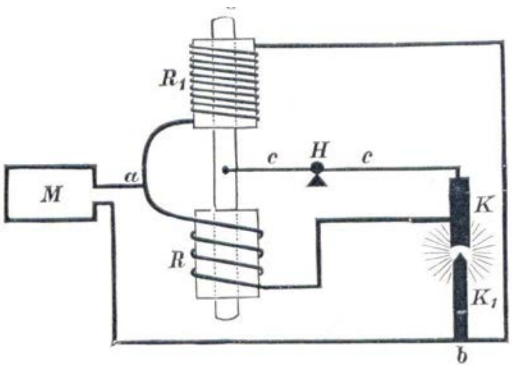
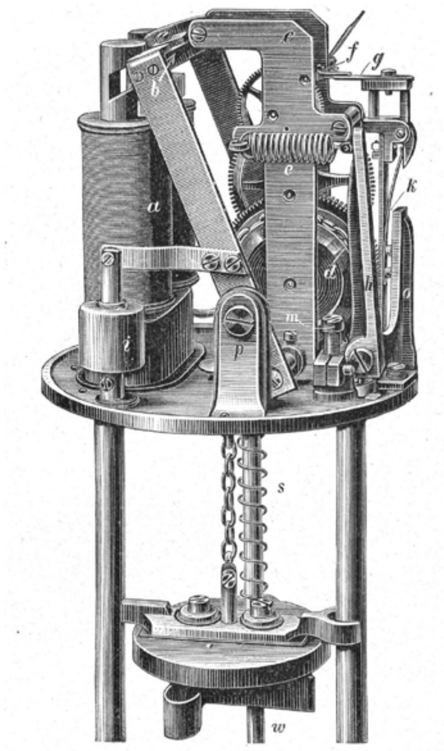


Fig. 13. Differential arc lamp

But the final construction of the DC differential lamps required further developments. One of them was the temperature compensation of the regulator. The excitation of the shunt coil is not directly proportional to the voltage but depends on the resistance. The attractive force (F) of the electromagnet is proportional to the product of the current and the number of turns of the coil: F = k x I x n (k: a constant depending on the dimensions of the electromagnet, I: the current, n: the number of turns). By the current can be measured the voltage U (U = I x R), but must be compensated for the change of the resistance at different temperatures. Between 0^{o} C and 60^{o} C (it is usual in the lamps of street lighting) it causes about 25% error of measurement. It was compensated mechanically by a bimetallic strip which provided an additional force supplementing the force of the electromagnet at higher temperatures (Fig. 14).



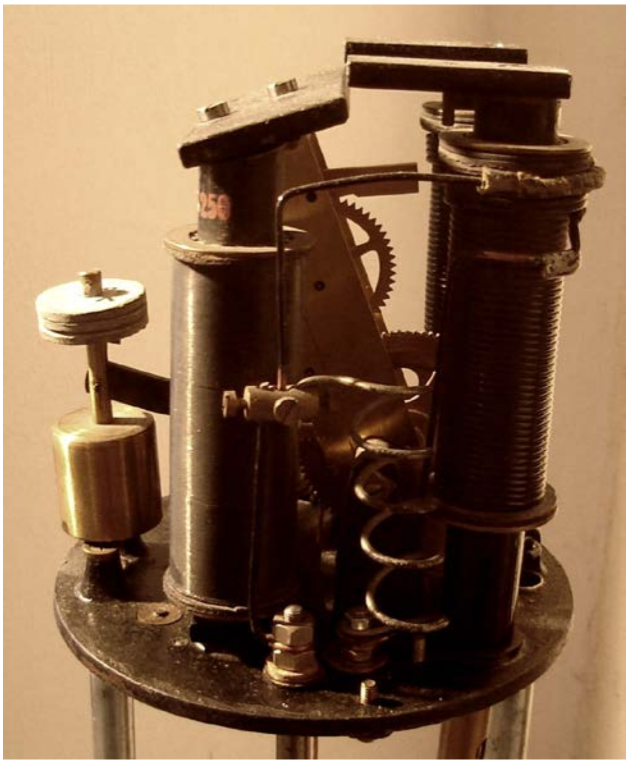


Fig. 14. Bimetallic temperature compensator (K)

Fig. 15. Kép Piston-type damper (on the left side)

Another problem was oscillation of the feedback control, which was damped mechanically by a piston-type damper (Fig. 15). The regulator was a masterpiece of the precision-mechanical and watchmaking industry.

5. A new technology: the alternating current

From 1885, after the invention of the A.C. distribution system with transformers the inventors, the ingenieur Trias of the firm Ganz, Zipernowsky, Déri and Bláthy had to construct AC devices, including AC arc lamps.

The starting point was the induction type consumption meter of Bláthy with a Ferraris-disc (Fig. 16). The number of turns of the disc was proportional to the consumption. Bláthy used the Ferraris disc as motor to drive the carbon rods. This function of the disc differed from the function in the consumption meter: in the meter it was a multiplier (U x I = W), in the AC differential lamp it was a ratio meter (U/I = R), it controlled the resistance of the arc, like in the DC differential lamp of Hefner-Alteneck. Actually the disc was the common rotor of two single-phase split-pole AC motors, one supplied by the current, the other by the voltage of the arc. The torque of the two motors was opposed. The "voltage-motor" drew the rods together, the current motor drew them back. After switching on the „voltage-motor" drew and touched the rods together. It produced a high peak current, the "current-motor" drew back the rods, the two effects got into equilibrium and stabilized the arc discharge. The construction of the lamp was very simple because it needed neither temperature compensation nor mechanical damping (Fig. 17). The impedance (AC resistance) of the voltage coil is mostly inductance. It doesn't depend on its temperature. The change in Ohmic resistance is negligible. The mechanical swingings induce eddy currents in the Ferraris disc between the poles of the stators that brakes them, so a mechanical damper is unnecessary. [7]

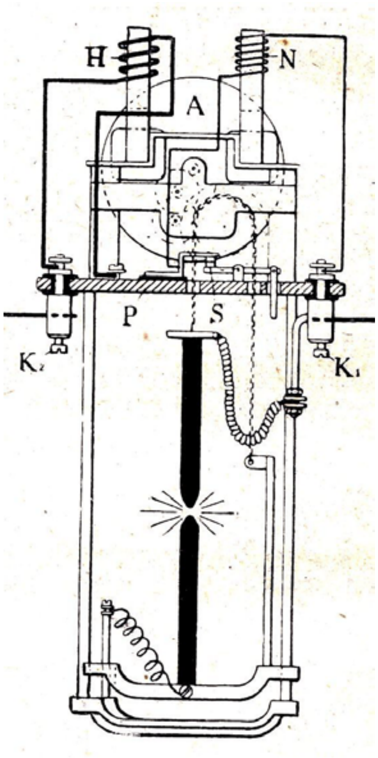


Fig. 16. Operation diagram of the Ferraris-disc AC arc lamp (AEG)

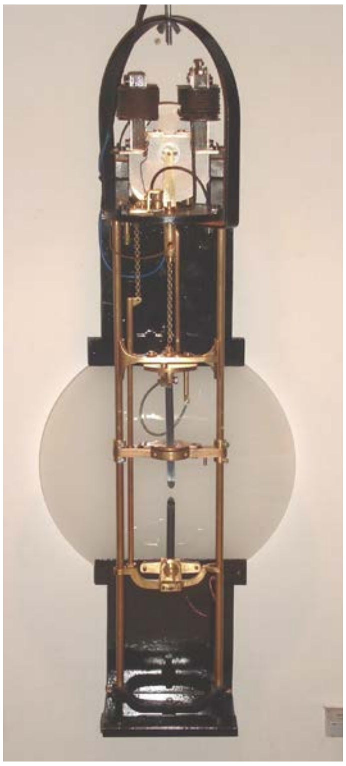


Fig. 17. Ferraris-disc AC arc lamp (AEG)

Fig. 18. The AC arc lamp in operation (AEG)

The efficiency of the arc lamps was very good, about 60-80 lm/W, 20-times higher than that of the carbon filament incandescent lamps, and 6-8 higher than that of the tungsten filament lamps, therefore they remained in use for public lighting and in projectors up to the 1940s, only the mercury- and later the sodium discharge lamps could replace them (Fig. 18).

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Fig. 4 Dr. L. Graetz: Die Elektrizität und ihre Anwendungen, 18. Aufl. p. 514., Fig. 460.
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Fig. 17 Photo by the Author.
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A new look at the Pixii machine – the first electric generator [1]

Brian Bowers, Ph.D. CEng FIET, formerly in the Science Museum, London

Abstract

Most electricity is generated by rotating a magnet near a coil of wire (or rotating a coil near a fixed magnet). The first such 'generator' was made by Hippolyte Pixii in 1832. The current induced in the coil reversed at each half revolution. André-Marie Ampère suggested a switching arrangement operated by a cam on the axis to change the connections and make the output unidirectional. The generator could then replace a battery. The Pixii firm made several such generators but Ampère's switch was soon replaced by the 'commutator' with sliding contacts. Ampère's contribution to generator development was quickly forgotten.

1. Introduction

The year 1832 saw a fundamental development in electrical engineering. The first generator whose output was, in principle, unlimited was made late that year by the leading French instrument makers, Pixii, père et fils. It was the forerunner of all modern electric generators. In the previous October Michael Faraday had demonstrated that brief pulses of electricity can be produced when a magnet is moved near a wire.[2] Faraday simply held the magnet in his hand, but to be of practical use for producing electricity the arrangement had to be mechanised. Two Italian physicists did this.

Leopoldo Nobili (1784-1835), professor in Florence, made a simple device, now in the Museo Galileo in Florence, in which a coil was mounted on a moveable arm so that it could be brought close to a permanent magnet and then pulled away. Salvatore Dal Negro (1768-1839), of Padua, wrote a paper describing an arrangement which he called his 'Electro-motive Battery'. There was no illustration, but he described four pairs of coils fixed in a line and four horse-shoe magnets on a trolley arranged so all the poles of the magnets could move into and out of the coils simultaneously, generating pulses of current. Dal Negro said 'Although these electric currents are ... of instantaneous duration ... with my battery they may be excited successively with such speed as to produce an action which is effectively continuous.' Dal Negro sent his paper to Faraday who arranged for it to be published in July 1832.[3] Faraday added a note.[4] 'I have described at length a different but perfect way of obtaining a continuous current by magneto-electric induction'. He was referring to his disc generator in which a copper disc is rotated between the poles of a horse-shoe magnet. Faraday's device did produce a continuous current, but the output was limited by the fact that only a single conductor, the radius of the disc, cut through the magnetic field.

2. Pixii, père et fils, and their magneto-electric generator

Nicolas Constant Pixii (1776-1861) took over the leading French instrument makers, the Dumotiez brothers, in 1818. He was the son-in-law of one of the Dumotiez, and together with his son (Antoine)

Hippolyte Pixii (1808-1835) developed the business, making a range of physical, chemical, optical, mathematical and other scientific instruments for customers across Europe and in America, as well as in France.[5] The machine for which the Pixiis are best known, and the one which concerns us now, is their magneto-electric generator first announced in three short reports in late 1832 in the Annales de Chimie et de Physique.[6] It is somewhat misleading to refer to the Pixii machine, because there were three versions in quick succession, each being an improvement on the previous one and each being reported to Monday evening meetings of the Académie des Sciences.

The first announcement was made on 3 September 1832 by Jean Nicolas Pierre Hachette (1769-1834), a mathematician and teacher with a strong interest in machines. He described a device 'constructed by the son of M. Pixii, the physical instrument maker', which gave a continuous stream of electric sparks. There was no illustration with the report, but Hachette said the apparatus consisted of two horseshoes with the same opening and arranged end to end. One horseshoe was of magnetized steel and could be rotated about its axis. The other was of soft iron and wound with 50 metres of silk-covered copper wire. The magnetized steel had a rectangular cross section of 35 by 10 mm and was 210 mm long. The soft iron was circular, 15 mm in diameter. The ends of the wire were close to (but not quite touching) mercury in a glass vessel, and sparks were produced when the wires touched the mercury as the machine vibrated as the magnetised horseshoe was rotated.

Five weeks later Hachette reported that if the wires ended in a vessel of water then hydrogen and oxygen were produced, mixed together.

The third report, on 29 October 1832, was by Ampère who announced an experiment using the apparatus just described together with a switching arrangement devised by Ampère himself. This was the 'bascule', or rocking switch, which was moved by a cam on the shaft of the machine and reversed the connections at each half revolution of the magnet. Hydrogen and oxygen could then be collected separately.

In addition to the three published reports there was a printed leaflet "Instruction pour remonter l'appareil magnéto-électrique", which accompanied the machine.

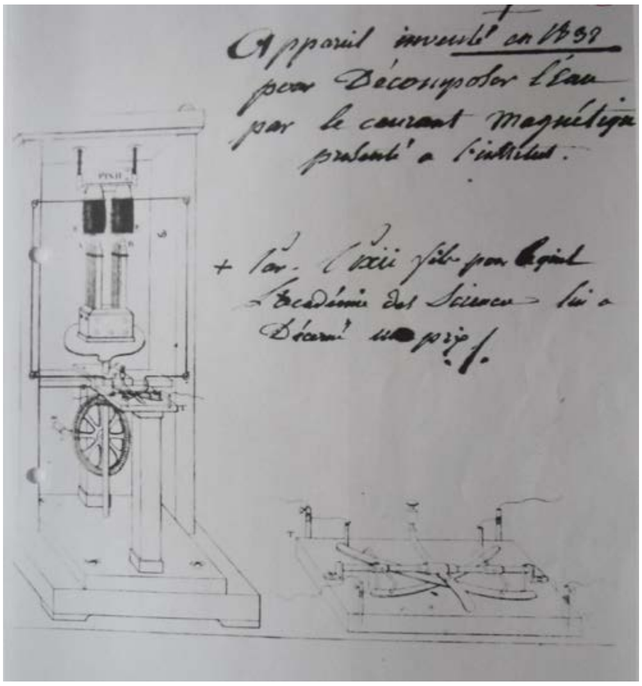


Fig. 1. Drawing in Instruction pour remonter l'appareil magnéto-électrique. The manuscript note is by Sir Francis Ronalds.

This leaflet was illustrated,[7] providing us with the earliest illustration of a Pixii machine with the rocking switch (Fig. 1, and redrawn in Fig. 1A). There is no printed date on this leaflet, but the copy in the Ronalds' Library has 'Appareil inventé en 1832 pour Décomposer l'eau par le courant Magnétique presenté à l'institute' written on it by hand.

In December the same year the Pixiis published a twenty-page article "Nouveaux appareils électro-magétiques pour lesquels l'Académie des Sciences a, dans sa séance du 26 novembre 1832, décerné un prix a M. Pixii (Hippolyte)".[8] This was one of the four de Montyon prizes awarded annually,[9] this one being for the 'invention or perfection of instruments useful in the progress of agriculture, the mechanical arts and the sciences'.

The purpose of the machine was clearly stated. 'This apparatus can replace the pile with advantage. When used in medical treatment it functions all the time, without using acid, without needing any preparation, and without any deterioration.'[10]

The article describes four Pixii machines, of different sizes, which the Pixiis were willing to make and sell. It tells us the strength of the permanent magnets, but does not give the dimensions of the machines.

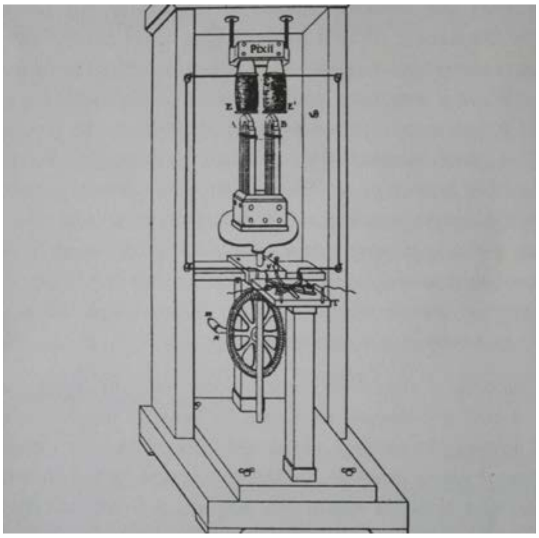


Fig. 1. Another drawing of the Pixii machine

The first, which was presented to the Académie des Sciences, had a magnet which could support 120 kilogrammes. The price was 1200 francs. The second, made for the École Polytechnique, had a magnet supporting 60 kg and cost 700 fr. The third, for the Faculté de Médecine, had a magnet supporting 30 kg and cost 500 fr. (a note in the paper says that several of the last size had been made for various establishments). They also made, for 180 fr., smaller machines which produced a continuous series of sparks but which could not decompose water.

3. Surviving Pixii machines with the Ampère switch

It would be very interesting to know how many machines with the Ampère switch were made, but it is impossible to find out. Paolo Brenni estimates about twenty.[11] At least four Pixii machines with the Ampère switch survive in museums today. They were all probably made in 1832, or very soon after. The machine with which the present writer is most familiar is in the National Museum of American History in Washington. They acquired it in the 1960s from the University of Virginia, who had probably purchased it when new.[12] In 1971 it was borrowed by the Science Museum in London, and a copy made. It stands just one metre high. The base is 540 by 370 mm. The soft iron core is 45 mm in diameter with limbs about 180 mm long. The permanent magnet, which is three pieces clamped together, has a cross section of 29 by 36 mm, and limbs about 250 mm long. The space between the poles is 65 mm.

The Science Museum copy (Fig. 2) can be operated. The mechanism is noisy and there is considerable vibration. A few minutes working the machine will convince anyone that although it demonstrated the possibility of converting mechanical energy into electrical energy, it was not a very practical way of doing so.

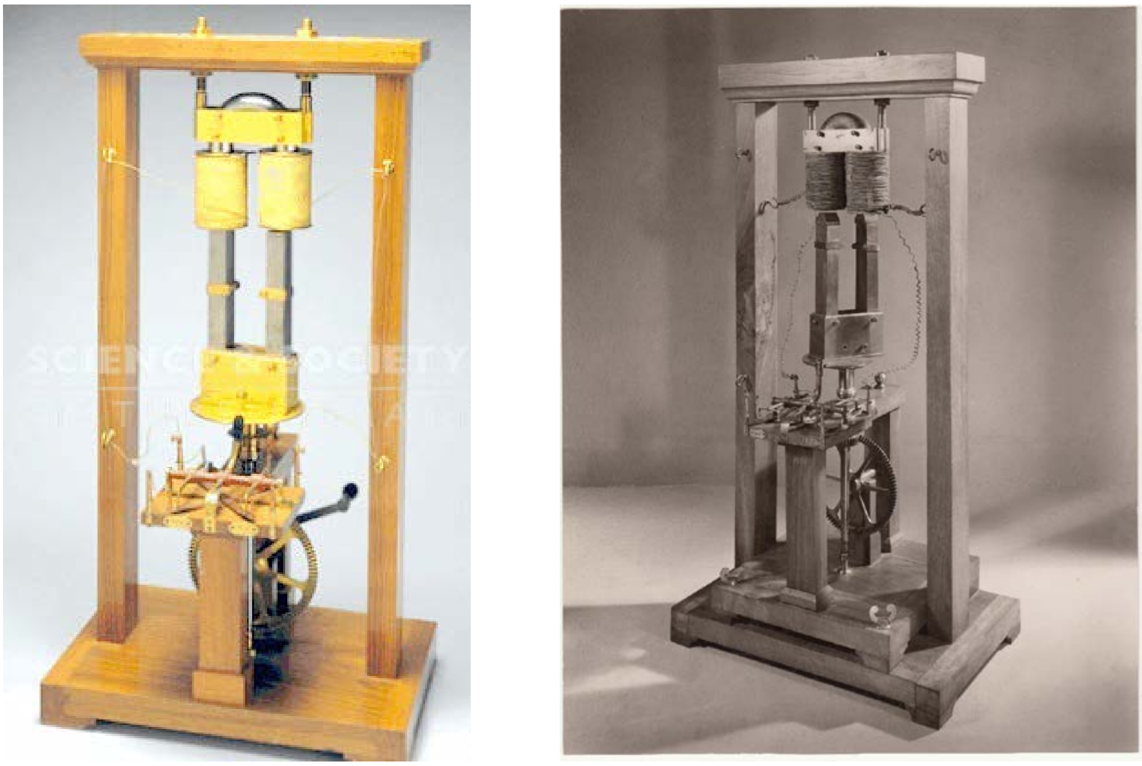


Fig. 2. The Pixii machine in the Science Museum, London, copied from the machine in the National Museum of American History

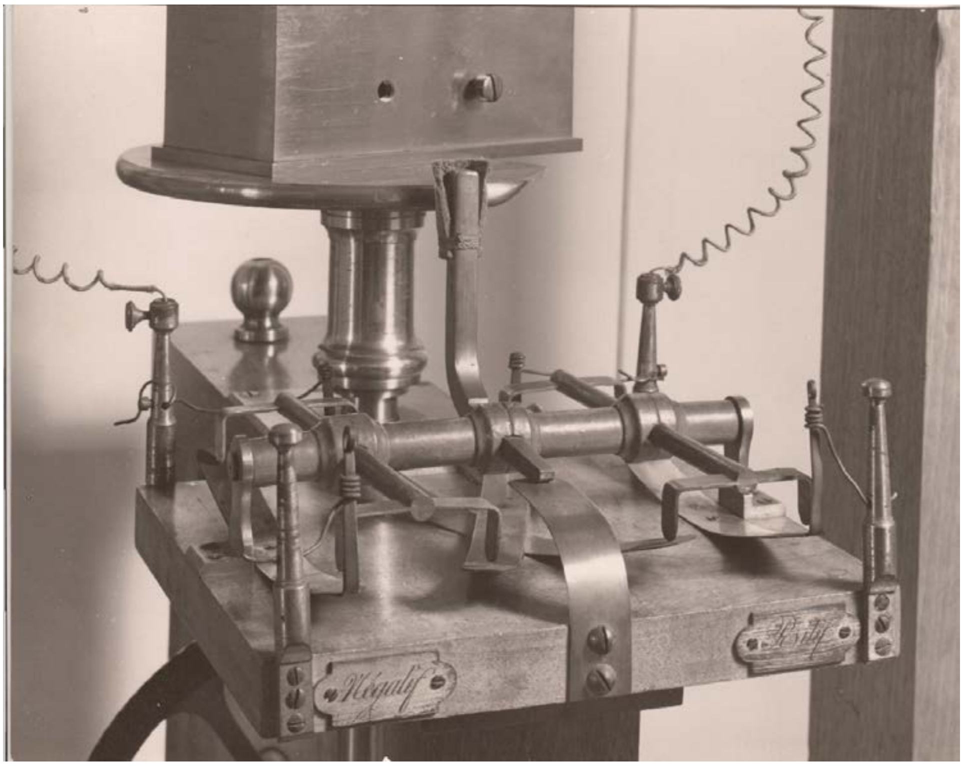


Fig. 3. The Pixii machine in the Deutsches Museum and a close view of the Ampère switch

Fig. 4. Three views of the Pixii machine in the Museo Galileo in Florence

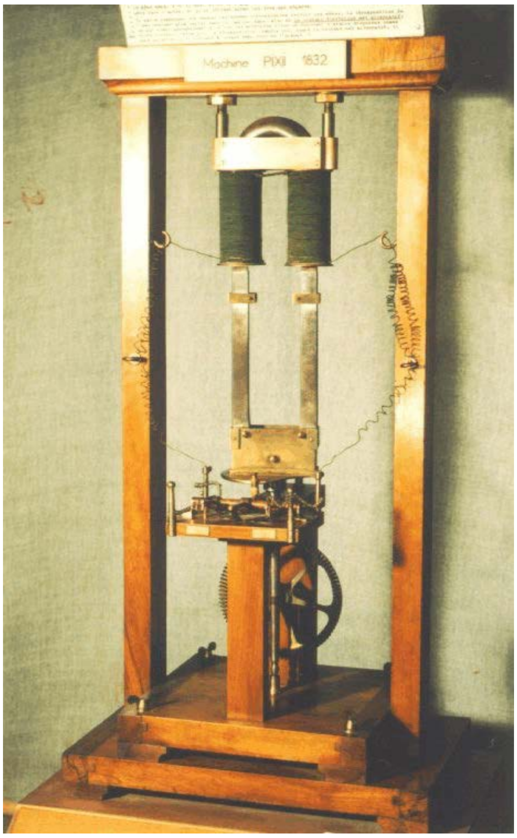


Fig. 5. Pixii machine in the Musée d'Ampère in Lyons

Fig. 6. Electromagnet used by Bancalari in his researchon the magnetic properties of gases, apparently takenfrom a Pixii machine.

The Deutsches Museum in Munich has a machine (Fig. 3) made in 1833, which was then in Munich.[13] Although looking in rather poor condition this machine appears to be complete. The Museo Galileo in Florence has a Pixii machine which looks in very good condition, except that the coils are missing (Fig. 4). The Musée d'Ampère in Lyons has a complete Pixii machine (Fig. 5).

There is also evidence that there was once a Pixii machine in Genoa. The professor of natural philosophy there, Padre Bancalari, showed in 1847 that flames are diamagnetic and could be moved by a magnetic field. To produce the magnetic field he used what appears to be the soft iron core and coils of a Pixii machine (Fig. 6).

Looking at the pictures of the surviving Pixii machines it is seen that they are similar, but not identical, suggesting that they were made to order with material currently to hand rather than being a stock item of which several were made at one time.

Hippolyte Pixii died in 1835, but the father carried on the firm and continued to make Pixii machines. They are described in a German publication of 1837[14] which, although written five years after the first machines were made, uses the illustration from Pixii's 'Instructions pour remonter ...' and does not suggest that there have been any changes in the design. The main application suggested is electrochemical decomposition.

A catalogue issued by the Pixii firm in 1845[15] shows that they were still making the machine then. The catalogue lists 807 items, and No. 542 is the Pixii machine with the comment that it was with this apparatus, invented by Pixii in 1832, that for the first time water was decomposed by magnetism. That machine cost 300 francs. They also offered a larger one, similar to that at the College de France, for 600 francs and smaller ones at 60 and 90 francs. The catalogue is not illustrated, so it is impossible to know for certain whether the machines being advertized in 1845 were the original design with the Ampère switch or the later design, discussed below, with a simple rotary commutator. The lower prices in the 1845 catalogue suggest that it was the simplified machine.

4. Development of the Pixii Machine

The first Pixii machines as described above had two fundamental limitations. The Ampère switch successfully converted the alternating current in the coils to a uni directional current, but it could not be operated faster than a few reversals per second and it could only switch a small current. Furthermore, rotating the heavy permanent magnet at speed made the whole machine vibrate.

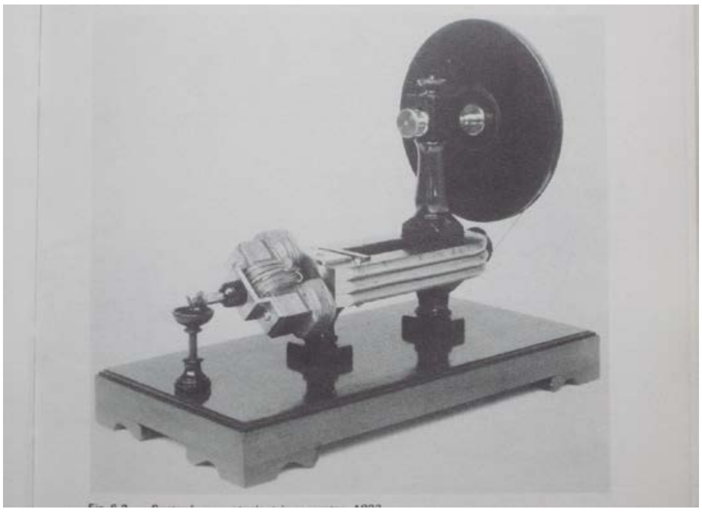


Fig. 7. Saxton's machine

The way forward was to rotate the coils rather than the permanent magnet, and to replace the Ampère switch with a commutator, that is contacts connected to the coils and arranged around a cylinder on the axis with springy fixed contacts pressing on them. These developments seem to have been due to Joseph Saxton (1799-1873), an American inventor and instrument maker who was living in London in the early 1830s. His machine was similar to the Pixii machine but the permanent magnet was fixed and the much smaller soft iron member which carried the coils rotated. (Fig. 7) The instrument maker E.M. Clarke made a similar machine but its coils were rotated alongside the permanent magnet rather than at the end.

Saxton's machine was exhibited at the Adelaide Gallery which opened in London on 4 June 1832 by the Society for the Illustration and Encouragement of Practical Science. Their aim was to inspire enthusiasm for science and technology by showing working models in action. On 14 November 1833 a public demonstration was arranged in the Adelaide Gallery in which a Saxton machine and a Pixii machine, provided by Count di Prediville, were compared. Unfortunately no account of the demonstration survives.

The fact that the first Pixii machines used Ampère's switch was quickly forgotten. Subsequent writers acknowledge Pixii's priority, but only describe the machine with a rotary commutator. In his comprehensive book on electrical machines, which was published in several languages, the French writer Amédée Guillemin (1826-1893) commented: 'Pixii's apparatus had the inconvenience of being troublesome to work, because of the weight of the magnet. It was found useful to increase the weight of this permanent magnet, whilst the electro-magnet could be made less massive. This inconvenience suggested the idea of moving the latter, and on the contrary, fixing the magnet. Hence a simple modification due to Saxton, who further placed the magnet in a horizontal plane, and made the induced bobbin move round an axle situated in this plane.'[16]

In 1884 Silvanus P. Thompson, professor of physics and electrical engineering in the City and Guilds of London Technical College, published the first edition of his Dynamo Electric Machinery, a comprehensive study of electrical machines which ran to seven editions over the following years. He mentions the Pixii machine, with an illustration copied from Guillemin's book (Fig. 8), but not the Ampère switch. Thompson's sources were various publications in French, German and Italian.

Guillemin commented that 'The name magneto-electric machines was given by Faraday to some form of apparatus for producing induction currents by revolving conductors in a magnetic field.' He also said that 'Pixii's machine . . . was the first induction machine that was put on the market. For that reason it deserves mention, though its use has long been abandoned'.[17]

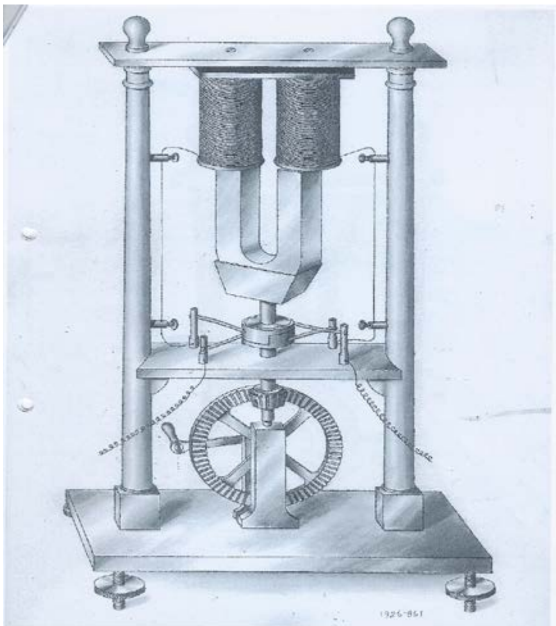


Fig. 8. Guillemin's drawing of a Pixii machine, with commutator

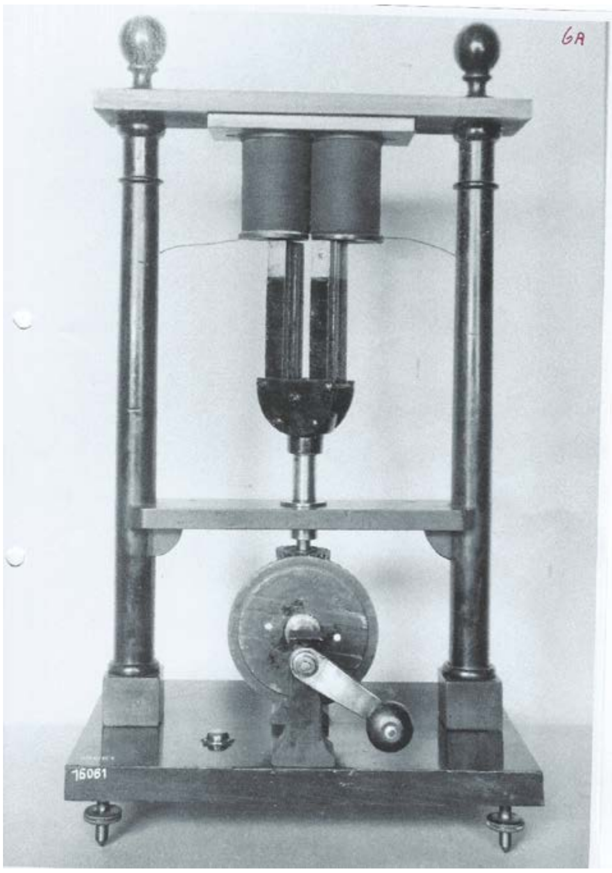


Fig. 9. Pixii machine made for the Deutsches Museum in 1908

5. The Ampère switch forgotten

In the late nineteenth and twentieth centuries several museums exhibited machines which were described as copies of Pixii's 1831 machine but did not have the Ampère rocking switch. The Deutsches Museum has one[18] made in 1908 by Simonis Werkstatte[19] (Fig. 9).

The Science Museum, London, had nothing on Pixii until 1926 when it exhibited a drawing of a Pixii machine with a rotary commutator[20] (Fig. 10). In 1933 the Science Museum published a catalogue of the Electric Power Collection including that drawing with a description which states that at Ampere's suggestion a simple commutator was mounted below the permanent magnet, and the output current rectified.

"Immediately after the publication of the results of Faraday's researches inventors began to make applications of magneto-electricity. H. Pixii, at the end of 1831, produced the machine represented, and a year later at the suggestion of Ampère added the simple commutator to rectify the alternating current produced and provide a unidirectional current in the external circuit."

"In Pixii's machine a permanent magnet mounted on a vertical shaft is rapidly rotated by hand, by means of gearing, its poles passing close to the faces of a soft iron horse-shoe, carrying bobbins of insulated wire. The induced current is led to the commutator mounted below the permanent magnet and there rectified."

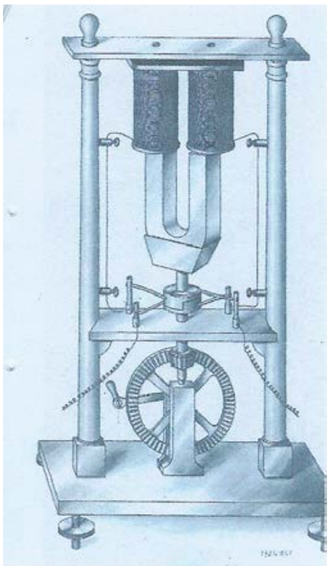


Fig. 10. Drawing exhibited in 1933 in the Science Museum

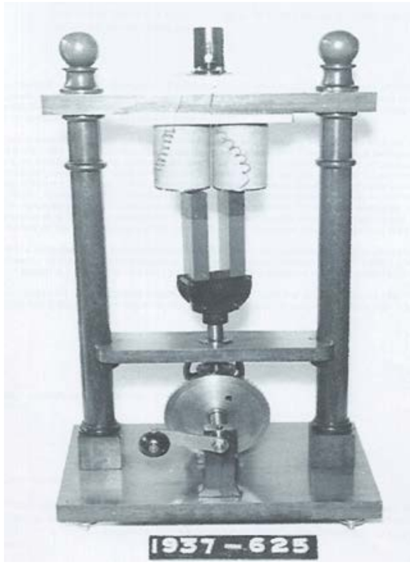


Fig. 11. Copy Pixii machine made in the Science Museum in 1937

Four years later, in 1937, a machine described as a replica of 'Pixii's magneto-electric machine, 1831' was made in the museum workshops[21] at the request of W.T. O'Dea, the then curator of electrical engineering. A photograph (Fig. 11) of the machine[22] taken at the time shows that there was no commutator but there is clearly room on the shaft, below the magnet, for a commutator to be added. A record photo on the Inventory Card, taken later, also shows that there was no commutator. The exhibition label for this object has almost the same text as the 1933 catalogue but the last sentence has been changed to 'The induced current was later led to a commutator mounted below the permanent magnet and there rectified'. This label was presumably written when the machine was first put on exhibition, in 1937. The writer cannot have read the statement in Annales de Chimie that Ampère proposed a commutating arrangement in the following month - not 'a year later'. The year is also wrong, since the Annales is clearly dated 1832. The writer would not have used the phrase 'a simple commutator' if it had been appreciated that the commutator Ampère proposed was the cam-operated switch rather than a rotating commutator with sliding contacts.

The Electric Power Collection was redisplayed in 1957[23] and the then curator, Margaret Weston, had a commutator added to the machine.[24] This machine was later given to the Riksutställningar (the Swedish Travelling Museum Service), who no longer have the machine, nor any record or photograph of it.[25].

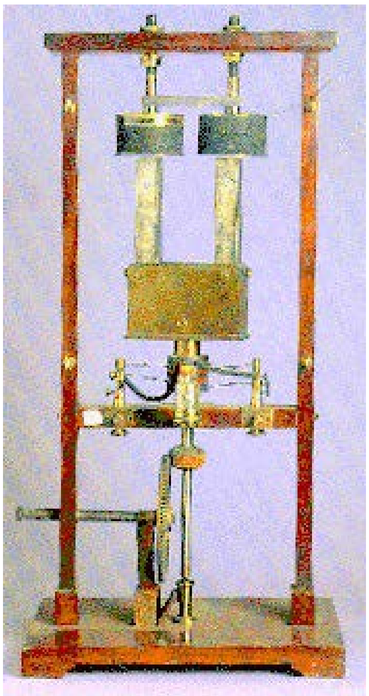


Fig. 12. Machine in the Musée Scientifique of the Lycée Louis le Grand

Fig. 13. Pixii machine made in 1891 in the Musée du CNAM

In 1962 the late Dr. Percy Dunsheath published a history of electrical engineering in which he acknowledged help given by the Science Museum in its preparation. He included a drawing which is a simplified version of the drawing the Science Museum exhibited in 1926.

Presumably no one from the Science Museum had seen any Pixii machine with the Ampère switch and appreciated its significance before the collection was redisplayed in 1957, although the Science Museum Annual Report for 1957 records that Margaret Weston visited the Deutsches Museum, and technical museums in Paris, later the same year. In 1966 she visited the Smithsonian, saw their Pixii machine with the Ampère commutator and, realizing its importance, made arrangements to borrow it for exhibition in London.[26] The following year I joined the Science Museum as curator of electrical engineering and while the Smithsonian machine was in London I had a copy made in the Science Museum Workshops.[27]

There is no Pixii machine with the Ampère commutator in Paris. The Lycée Louis le Grand has, in its Musée Scientifique, a machine by Pixii (Fig. 12) which they date to 1832, but it has a conventional commutator and the soft iron armature is quite different to that in the original Pixii machines.[28] The Musée du CNAM has a Pixii machine which they purchased in 1891. This has a conventional commutator and is inscribed 'Machine Pixii et Ducretet, à Paris' [29] (Fig. 13).

6. Conclusions

Using the Ampère switch was an important step in the development of the Pixii machine, and therefore of electric generators. It was, however, soon replaced by what is now regarded as a conventional commutator. Ampère's switch was quickly forgotten and this significant part of the story was no longer mentioned in accounts of the development of electrical machines.

References

1 Paper originally presented at a seminar at the Museo della Tecnica Elettrica, Pavia, 6 September 2013.

2 Phil. Trans. 1832, pp. 125-162.

3 'New experiments relative to the Action of Magnetism on Electro-dynamic spirals, and a Description of a new Electro-motive Battery', Phil. Mag. third series, vol. 1, published July 1832., pp. 45-49.

4 'New experiments relative to the Action of Magnetism on Electro-dynamic spirals, and a Description of a new Electro-motive Battery', p. 46.

5 Paolo Brenni, 'Dumotiez and Pixii: The Transformation of French Philosophical Instruments', Bulletin of the Scientific Instrument Society, No. 89, 2006, pp. 10-16.

6 Reports dated 3 September, 8 October and 29 October 1832.

7 There is a copy in the Ronalds' Library.

8 Bulletin de la Soc. Philomatique, (in the Bibliotheque Nationale, Paris).

9 Baron de Montyon endowed prizes which were awarded annually by the Académie Française.

10 The original wording is 'Cet appareil peut remplacer la pile avec avantage. Dans son emploi comme traitement médicale, il fonctionne en tout temps, sans emploi d'acide, sans aucune préparation, et sans aucune détérioration.'

11 Paolo Brenni, email to author 19 July 2013.

12 Bernard Finn, curator of electricity in the Smithsonian, acquired this machine from the University of Virginia in the 1960s,where it was still being used for demonstrations. The University had apparently purchased it at an early date. (Personal communication, January 2013).

13 Deutsches Museum Inv. 20908.

14 H. W. Dove and L. Moser, Repertorium der Physik, pp. 308-312, Berlin, 1837.

15 Catalogue des principaux instruments de physique ... qui se fabriquent chez Pixii, père et fils, Paris, 1845. (Copy inMusée du CNAM).

16 Amédée Guillemin, Le magnétisme et l'électricité, published 1890 according to the BnF catalogue générale. My quotations are taken from the English translation by Silvanus P. Thompson. There was also a Hungarian translation, and I am grateful to Sàndor Jeszenszky for drawing it to my attention.

17 pp. 398 - 400.

18 Object number 16061, photo number 2744.

19 Personal communication, Friedrich Heilbronner, 13 October 2012.

20 Inv. 1926-861.

21 Inv. No. 1937-625.

22 Photo. 544/37

23 According to the Science Museum Annual Report for 1957 the Gallery opened on 20 May 1957, and the curator in charge, Margaret Weston, visited the Deutsches Museum and technological museums in Paris in the summer of that year.(Information provided by John Liffen, email 19 August 2013). (This must be the visit Margaret was remembering when she told me she had visited the Deutsches Museum when preparing Gallery 6. She has no recollection of seeing a Pixii machine with the rocking switch.)

24 This statement is based on conversations with Margaret Weston and with John Smart, who was her assistant at the time.

25 I am grateful to Elisabeth Drye for drawing my attention to this machine, and to Lionel Dufaux for the details. Personal communication, Margareta Carlson, Registrar Assistant, Riksutställingar.

26 Science Museum Annual Report for 1966. She was UK representative on a tour sponsored by the American Association of Museums.

27 I joined on 1 December 1967. The copy machine is Inventory No. 1972-332.

28 I am grateful to Robert Fox for bringing this machine to my notice.

29 CNAM Inv. No. 12,190. I am grateful to Elisabeth Drye for drawing my attention to this machine, and to Lionel Dufaux for the details.

Early Electric Generators in the Deutsches Museum

Dr. Ing. habil. Friedrich Heilbronner, retired from Deutsches Museum, München

Abstract

Generators of the 18th century produced electricity by friction and electric power was only a toy in form of high voltages from friction machines. The breakthrough towards power came shortly after Michael Faraday (1791-1867) had discovered magneto-electric induction in 1831. An early spectacular application of the "new" electric energy were lamps with the electric arc light, for which the engineers in many countries constructed electrical apparatus. The use of the iron's remanent magnetism - discovered in 1866/1867 and called "dynamo-electric principle" - and many constructional details perfected the electric generators and other machines. The relevant objects from the Deutsches Museum are presented.

1. Historical notice

Generators of the 18th century produced electricity by friction and electric power was only a toy in form of high voltages from friction machines. After the discovery of the battery by Alessandro Volta (1745-1827) in 1799, the dominant applications of electricity were:

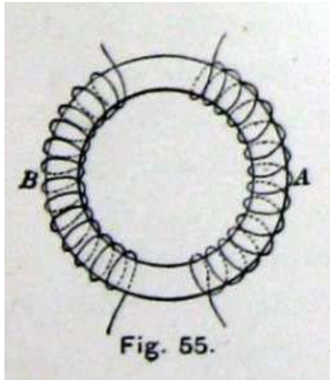
a) electroplating for consumer goods,

b) telegraphy on wires for the operation of railway systems,

c) electric power generation for electric lighting and replacement of power from steam.

The discovery of electromagnetism in April 1820 by Hans Christian Oersted (1777-1854) accelerated the development, but power from batteries was low. The breakthrough came with the magneto-electric machines shortly after Michael Faraday (1791-1867) had discovered magneto-electric induction in 1831 (Fig. 1).

The first apparatus in which the newly found law of induction was applied was built in Paris 1832 by Hippolyte Pixii (1808-1835); thereafter engineers in many countries constructed electrical machinery which delivered electric currents of high density and quantity by applying mechanical energy. Until the 1850s, permanent magnets were first used to induce voltage in a disc armature, then from the 1860s onwards, electromagnets with a core of iron came into usage – these machines were called electro-magnetic machines.



Faraday's original ring is preserved in the Science Museum London, in Munich is a replica (inv.-no. 65810) and an explanatory sketch.

The armature is the place where the voltage is induced and – if the circuit forms a closed loop – a current flows in the armature windings. The form of these windings in the armature were optimized to cut the magnetic fieldlines: from several coils (disc armature) to the ring armature by Antonio Pacinotti (1841-1912) in 1860 and ten years later by Zenobe Gramme (1826-1901).

After that, the drum armature, first constructed in 1872 by Friedrich von Hefner-Alteneck (1845-1904) became the dominating design of the rotors in power generators up to the present. A rotor can either be an armature or an electromagnet, it bears sliprings or a commutator for the supply current or for the generated current.

By use of the iron's remanent magnetism, separate generators for the exciting magnetic field became obsolete (1866/67 discovery of the dynamo-electric principle by Werner Siemens (1816-1892), Charles Wheatstone (1802-1875) and Cromwell F Varley (1818-1883) – the machines were called dynamo-electric machines.

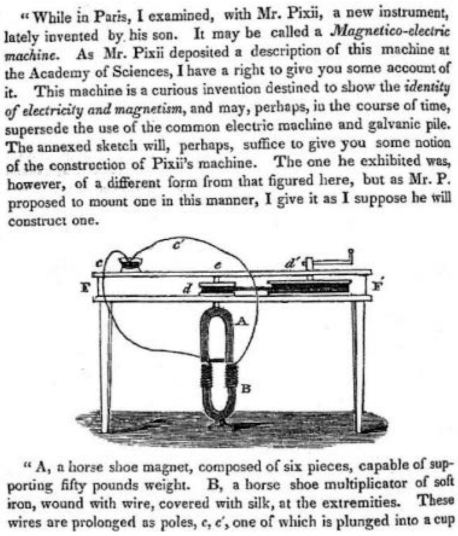
From then on, one generator could supply far more than one arc lamp.

2. Magneto-electric AC Machines

The Deutsches Museum has such machines from three manufacturers.

a) Hyppolyte Pixii (1808-1835)

Because the Pixii machines are treated in the forgoing paper by Brian Bowers with a photo of the machine (inv.-no. 20908) and a video presentation is available in the Internet under the link: <http://brunelleschi.imss.fi.it/museum/esim.asp?c=500081>, I bring one of the first published drawings of Pixii's ideas from the American Journal of Science and Arts. Here in the drawing, (Fig. 2), the steel magnet A rotates and the armature B stays fixed on the bottom board; no commutator is shown, which means that AC is produced, and it is questionable, if water is dissected by the wires c and c'.



"While in Paris, I examined, with Mr. Pixii, a new instrument, lately invented by his son. It may be called a *Magnetico-electric machine*. As Mr. Pixii deposited a description of this machine at the Academy of Sciences, I have a right to give you some account of it. This machine is a curious invention destined to show the *identity of electricity and magnetism*, and may, perhaps, in the course of time, supersede the use of the common electric machine and galvanic pile. The annexed sketch will, perhaps, suffice to give you some notion of the construction of Pixii's machine. The one he exhibited was, however, of a different form from that figured here, but as Mr. P. proposed to mount one in this manner, I give it as I suppose he will construct one.

"A, a horse shoe magnet, composed of six pieces, capable of supporting fifty pounds weight. B, a horse shoe multiplicator of soft iron, wound with wire, covered with silk, at the extremities. These wires are prolonged as poles, *c*, *c'*, one of which is plunged into a cup

Fig. 2. American Journal of Science and Arts 24(1833)1, p. 146: Letter from Dr. Charles T. Jackson, to the Editor, dated New York, Dec. 25, 1832.

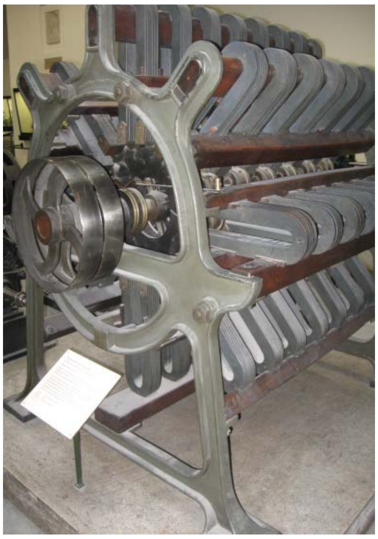
b) Emil Stöhrer (1813-1890)

Stöhrer was an instrument maker in Leipzig and changed Pixii's machine in so far as he kept the magnets fixed and turned the armature instead; there he connected several coils in series to form a so-called disc armature (Fig. 3). The commutator sits on top and has spring contacts. The historic context is published by F. Dittmann and J.-G. Hagmann, Deutsches Museum: Emil Stöhrer and the Development of Electrical Motor Technology in the 1840s, in: Proceedings of HISTELCON2012: The Origins of Electrotechnologies, Session 5-2. Pavia University, September 2012 (also published in Internet under IEEE-Xplore).

Fig. 3. Stöhrer's machine with disc armature, 1863 (inv.-no. 3902)

c) Société Anglo-française Alliance

The machines of this company were the first ones of practical use (Fig. 4): They generated enough current for the arc light in lighthouses where rocks endangered the safety of sea routes. They are still of the disc armature design, but several disc armatures are connected in parallel. The leading engineers were Floris Nollet (1794-1853), who died before his design became a success, and after him Auguste Berlioz and Joseph van Malderen – both of whom no lifeyears are known.



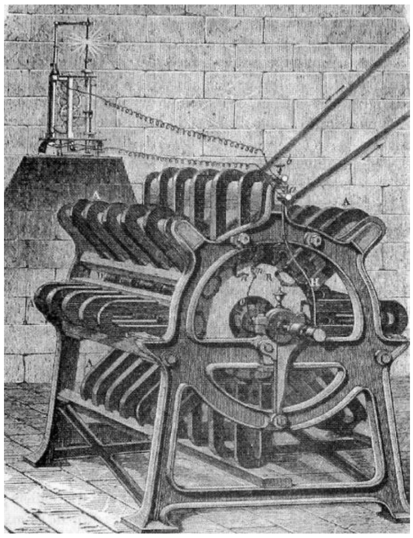


Fig. 4. At left: Alliance machine with disc armature, 1863 (inv-no. 18043). At right: Sketch of an Alliance machine in service, from: LeRoux, F. P.: Les machines magnétoélectriques françaises et l'application de l'électricité a l'éclairage des phares. Gauthier-Villars Paris 1868, 95 pp.

These machines were used in French lighthouses along the coast. The British had a similar design by Frederick Hale Holmes (1811-1870) for their lighthouses. The Deutsches Museum built in 1952 a diorama to illustrate the situation at the site of a famous French lighthouse, the lighthouse La Hève near Le Havre (inv.-no. 70003) (Fig. 5), (Fig. 6):

Fig. 5. Diorama with two lighthouses, 1952, in the centre: the powerhouse

Fig. 6. Detail of powerhouse with two Alliance machines

3. Electro-magnetic machines

The disc armatures were still in use over years, but the steel magnets were replaced by electromagnets, the current for the electromagnets came from separate dynamos what is now called external excitation – and still in practice in modern large units. I show three early generators from the Museum's stock.

a) One of the first designers of electro-magnetic DC machines of this type was Henry Wilde (1833-1919). His machine is so important that the Deutsches Museum had a replica made from the Science Museum's original 1865 (Fig. 7), (Fig. 8), (Fig. 9).

Fig. 7. Wilde's magneto-electric machine with external excitation, 1865 (inv.-no. 72434, replica)

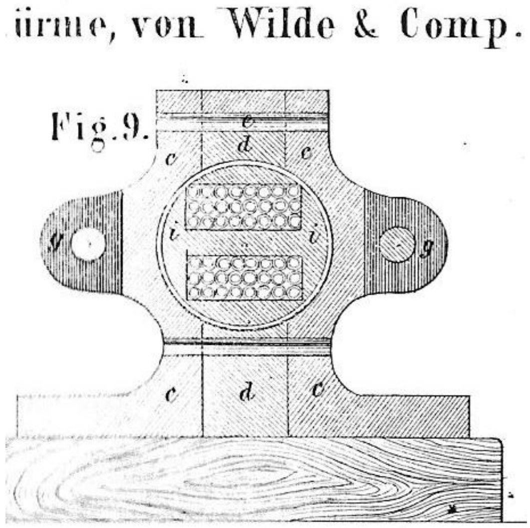


Fig. 8. The shuttle or double-T armature in detail (cross section)

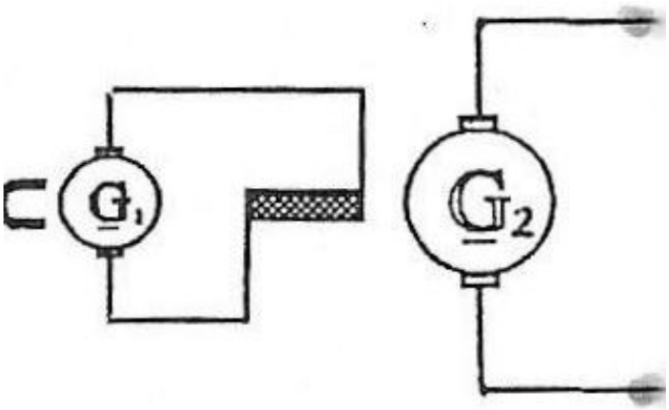


Fig. 9. The excitation scheme of Wilde's generator is quite modern: The horseshoe magnet on top excites the auxiliary generator G1 which supplies the current for the electromagnets of the main generator G2

b) The "external excitation" principle was applied by Friedrich von Hefner-Alteneck (1845-1904) also in an electro-magnetic AC generator with disc armature, in use to feed 2x5 = ten arc lamps in Munich main station; the external excitation came from a separate S&H dynamo as shown in the lower sketch "Alteneck's generator in service" (Fig. 10), (Fig. 11), (Fig. 12), (Fig. 13).

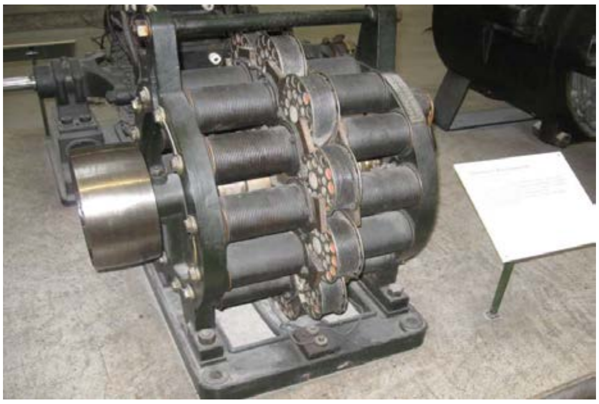


Fig. 10. Hefner-Alteneck AC generator with disc armature, 1878 (inv.-no. 33611)

Fig. 11. Front view with sliprings indicating an AC generator

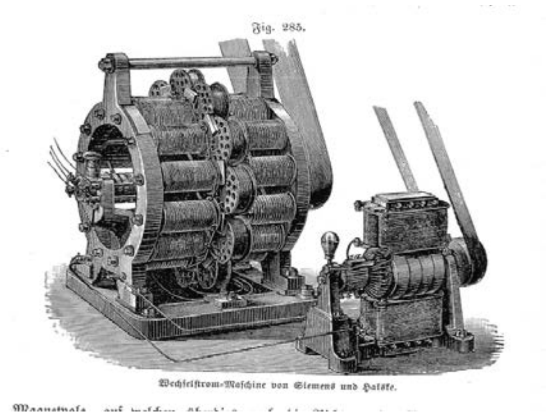


Fig 12. Alteneck's generator in service

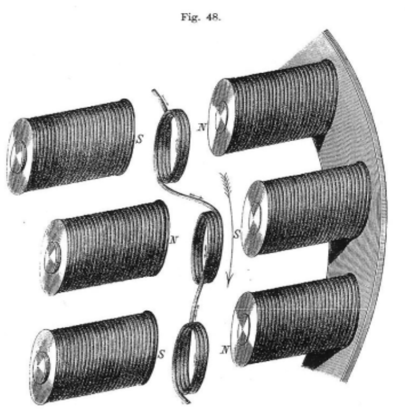


Fig 13. Detail of electromagnets and armature

In order to give an impression of such generators in service, a diorama (inv.-no. 70004) was built showing the situation in the departure hall of Munich main station, 1879 (Fig. 14).

Fig 14. Diorama of departure hall of Munich main station (inv.-no.70004)

S&H installed 45 arc lamps and the electricity for them was supplied by three AC generators with disc armatures (Hefner-Alteneck design) supplied the electricity for them.

c) At the same time, for similar purposes, Gramme also manufactured AC generators, but with ring-armatures (see later) (Fig. 15), (Fig. 16).

Fig. 15. Gramme AC ring-armature generator with 4 circuits to feed four Jablochkoff arc lamps, 1878 (inv.-no.12682)

Fig. 16. Front view

4. Dynamo-electric machines

In order to increase the efficiency in transforming the mechanical power into electricity, new types of armature were invented: the H or shuttle armature, the ring armature and finally, the drum armature.

1.) The H or shuttle armature

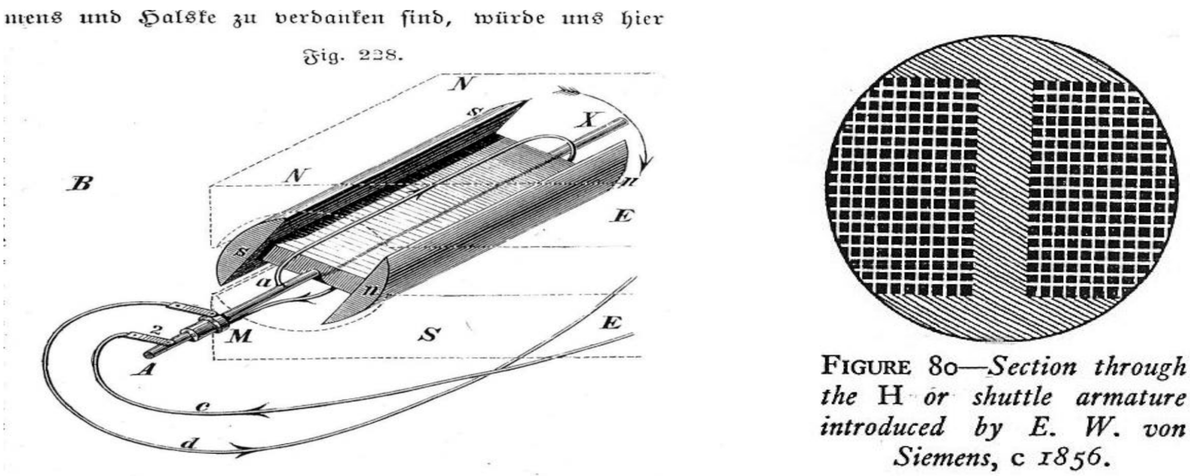


Fig. 17. Circuit and double-T armature

Around 1856, Werner Siemens, after nobilitation in 1888: Werner von Siemens (1816-1892) used soft-iron to concentrate the magnetic fieldlines and to minimize strayfields. The English literature speaks of “H or shuttle armature”, the German literature of “double-T armature” (Fig. 17). It depends how you look at it: the H can be made from two horizontal Ts (see also the cross section sketch at Wilde's machine).

The Deutsches Museum preserves Siemens' first machine with such an armature (inv.-no. 3566) and a sketch shows how it was used in service during an exhibition: watercooled with external excitation (Fig. 18).

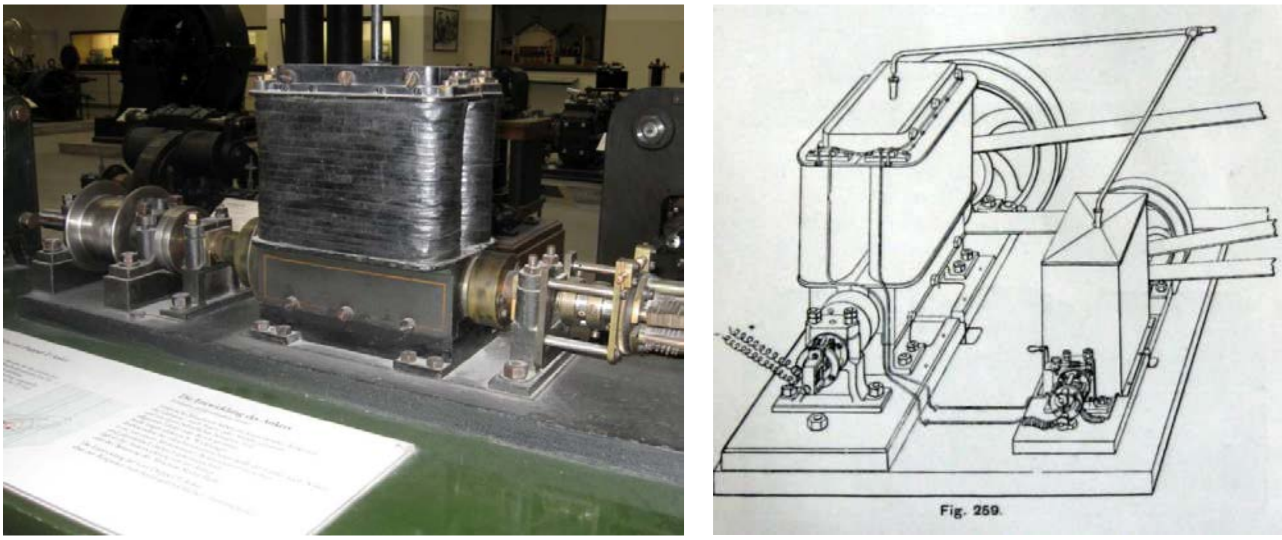


Fig. 18. Siemens' first generator with shuttle armature (inv.-no. 3566)

In 1866/1867, the use of the iron's residual magnetism was discovered in England and Germany and named "dynamo-electric principle": The current output of the generator increases until saturation of the iron occurs. The Deutsches Museum shows the original machine with which Siemens discovered this principle (Fig. 19): A series-wound dynamo for telegraph signals on railway lines (inv.-no. 59641). Although I haven't seen Wheatstones' dynamo, I know from literature that his was shunt-wound.

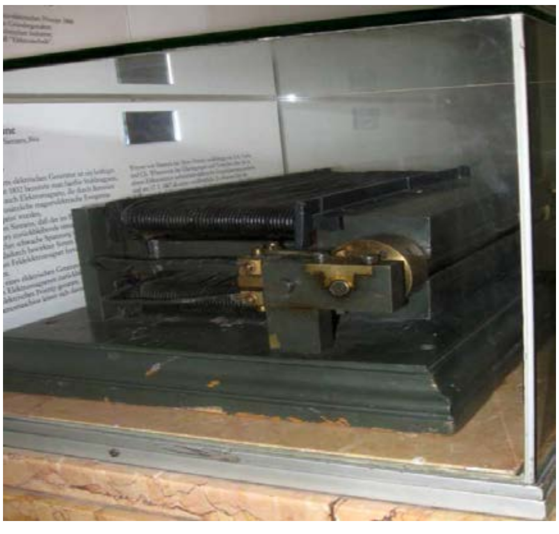


Fig. 19. Siemens' dynamo, 1866 (inv.-no. 59641)

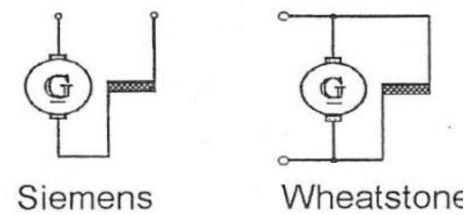


Fig. 20. Modern presentation

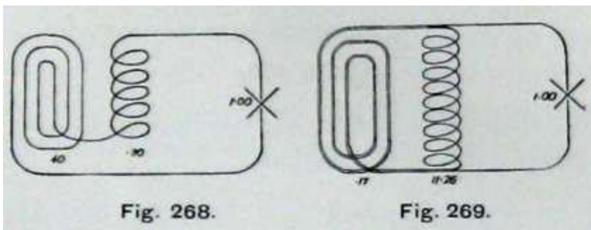


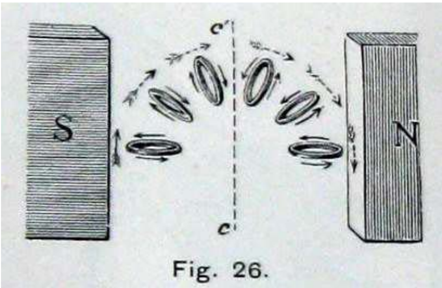
Fig. 21. Historic presentation 1881
left: series connection of electromagnet;
right: shunt connection

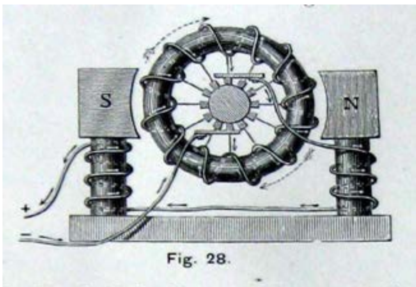
2.) The ring armature

The ring armature was invented in 1860 by Antonio Pacinotti (1841-1912); the Deutsches Museum displays a copy of the original device, donated by the Associazione Elettrotecnica Italiana in 1906 (Fig. 22).

Fig. 22. Pacinotti's ring armature generator, 1860 (replica, inv.-no. 7862)

The three following sketches might explain the design (Fig. 23), (Fig. 24), (Fig. 25):





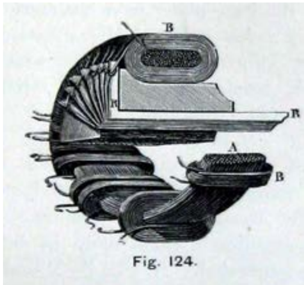


Fig. 23. Principle

Fig. 24. Functional sketch showing the commutator and the electromagnets

Fig. 25. Sketch of a Pacinotti-Gramme ring of a DC generator

Now, I present the generators of two inventors, who were commercially successful:

a) The Belgian-French engineer Zenobe Gramme (1826-1902) was the first industrialist who manufactured and sold commercial generators in great numbers. The electrotechnical exhibitions in Paris 1881 and Munich 1882 made his design widely known; in the royal castle Linderhof, 12 DC generators were installed – one of them came to the Deutsches Museum (Fig. 26), (Fig. 27).

Fig. 26. Gramme's machine from Linderhof, approx. 1880 (inv.-no. 36149)

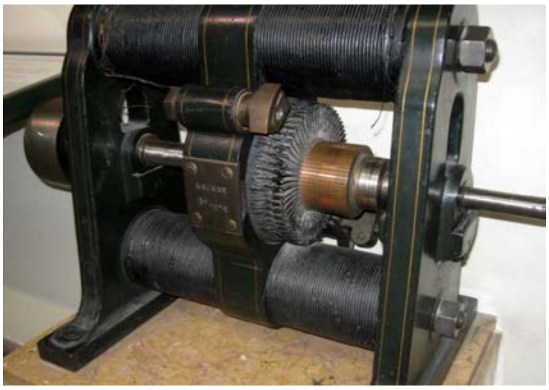


Fig. 27. Gramme's machine, approx. 1880 (inv.-no. 47797)

During the Munich exposition 1882, Oskar von Miller (1855-1934) was the exhibition engineer and he and the French engineer Marcel Deprez (1943-1918) gave a demonstration of a long distance DC power transmission which is remembered of by a painting in the Deutsches Museum (Fig. 28), (Fig. 29):

- distance: 57 km
- voltage: 1400 V
- sending power in Miesbach: 1.5 hp
- received in Munich: 0.4 hp

Fig 28.

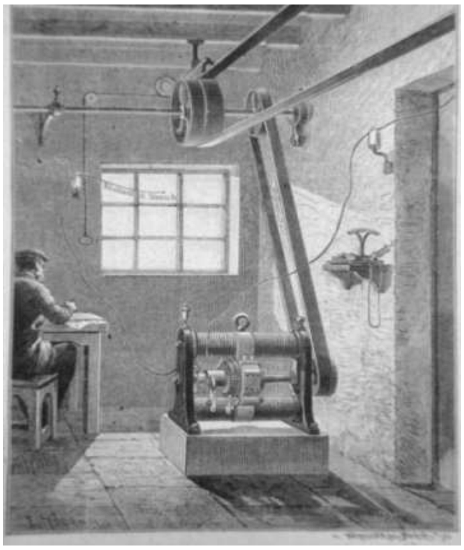


Fig 29. A contemporary drawing of the generator room in Miesbach shows a Gramme DC dynamo

b) Sigmund Schuckert (1846-1895) of Nürnberg improved the ring armature in such a way that the fieldlines could better penetrate the armature windings; he created dynamos with a flat-ring armature; they were widely used in different types and sizes. To improve the power output, two flat-ring armatures could be mounted on one axle (Fig. 30).

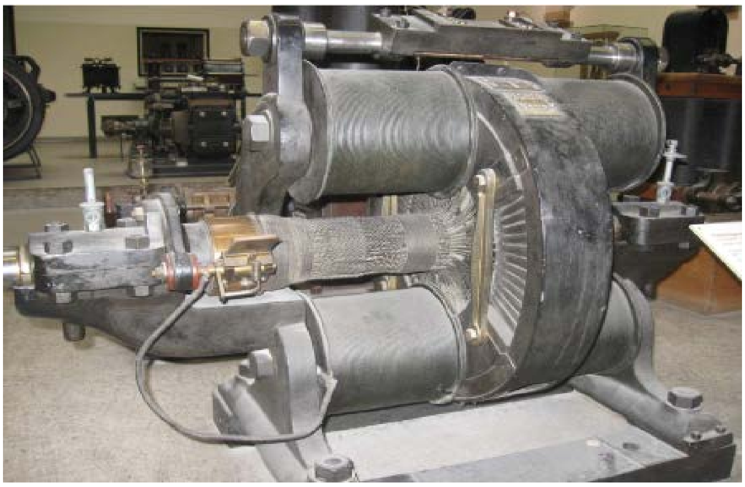


Fig. 30. Schuckert's flat-ring dynamo, 1883 (inv.-no. 3514)

3.) The drum-wound armature

By means of the drum-wound armature, the armature was comprehensively embraced by the electromagnetic fieldlines and the power output was increased, although ring armatures were manufactured approx. until 1893 (Fig. 31).

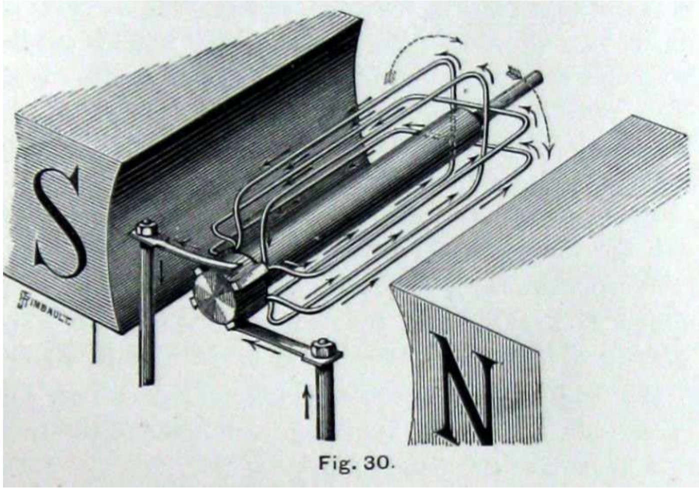


Fig. 31. Sketch of armature

The Deutsches Museum has early generators of two inventors:

a) Friedrich von Hefner-Alteneck (1845-1904) invented the drum-wound armature in 1872 while he was employed by the Siemens company (Fig. 32).

Fig. 32. This is his first machine, 1873 (inv.-no. 3568), a magneto-electric DC generator

From then on, Siemens & Halske in Berlin built electro-magnetic generators in various designs with the electromagnets mounted vertically or horizontally. In Fig. 33 I show a military object of our collection.

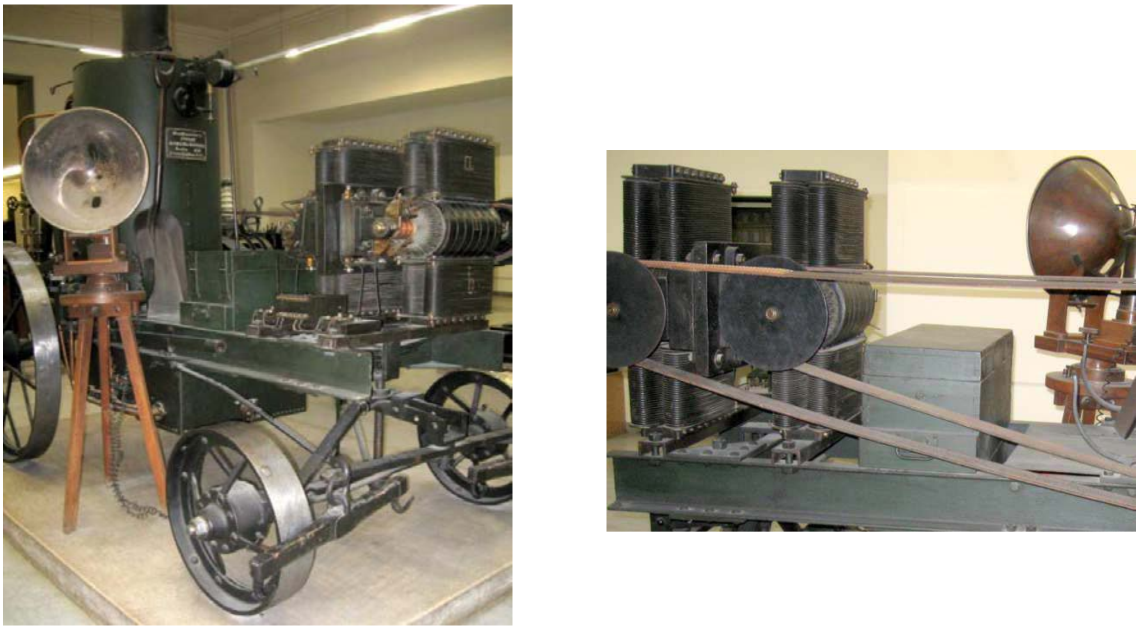


Fig. 33. At left: a double-dynamo in a horse-drawn vehicle (movable furnace and boiler) for arc light, 1878 (inv.-no. 20205). At right detail, seen from reverse side (inv.-no. 20205)

b) Thomas A. Edison (1847-1931)

I finish my lecture with two generators of this great American inventor, because he designed the first power plant: In the Pearl Street station in lower Manhattan on 4 September 1882, he presented a complete system of commercial electric lighting and power where the generator is only one part of the equipment. The Deutsches Museum exhibits one generator and has another one in storage to be restored (Fig. 35), (Fig. 36).

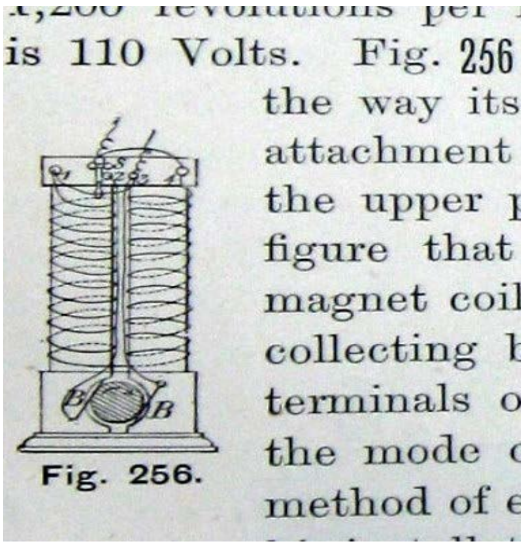

is 110 Volts. Fig. 256
the way its
attachment
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Fig. 34. Contemporary sketch showing the electromagnet's shunted windings

Fig. 35. Z-type "Long-Legged Mary Ann", Edison's first commercial dynamo, 1879 (inv.-no. 18326)

Fig. 36. Edison's K-type dynamo, 1882 (inv.-no. 17395)

This (Fig. 35) is Edison's first machine for electric light in Europe, a commercial DC machine with drum-wound armature and shunt-connection of the electromagnets. The output power was increased by mounting up to three units in parallel on one axle and ours (Fig. 36) dates from the year 1882, the year of the Munich international electricity exhibition. So, you may speculate, if this dynamo was exhibited there.

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by a click to the line: " zum erweiterten Register des Lexikons"

30 settembre 2013

Memorie di storia pavese
Memorabilia of local history in Pavia

Piccole ma significative reliquie di storia pavese sono entrate a far parte del patrimonio del Museo della Tecnica Elettrica dell'Università.

Sono il risultato della raccolta appassionata del dr L. Aricò, noto professionista pavese, che ha voluto che venissero custodite nel Museo.

Si tratta, in particolare, di un'azione della Società Elettrica Pavese istituita nel 1895 per produrre la prima luce elettrica per la città e di due altoparlanti a tromba impiegati in Piazza della Vittoria negli anni trenta per le grandi manifestazioni pubbliche.

L'Atto di donazione è stato firmato lunedì 30 settembre al Museo della Tecnica Elettrica dal donatore, dal Rettore dell'Università e dal Direttore del Museo.

Little yet meaningful relics of local history in Pavia have enriched the heritage of the Museum.

They come from the collection of a known professional from Pavia who decided that some results of his passionate work as a collector could be kept in the Museum.

Among them there are: a stock of the Società Elettrica Pavese, established in 1895 to provide the town with electric lighting and a couple of trumpet load-speakers used in the Pavia main square in the 1930s on the occasion of big events.

The donation act was signed on Monday September 30 in the Museum by the donor, the Rector of the University and the Director of the Museum.

Nuove acquisizioni / New Exhibits

Sabato 2 marzo è stata inaugurata “Forza, pedala!”, l’installazione didattica permanente che consiste in un esperimento di conversione di energia meccanica in energia elettrica grazie a bici generatori.

I bicigeneratori sono biciclette alla cui ruota posteriore è stato applicato un generatore di corrente. La forza cinetica prodotta dalla pedalata viene trasmessa al generatore e, come in una dinamo, i bicigeneratori producono energia elettrica pulita attraverso l'energia meccanica.

Tre postazioni sono state collegate per l’occasione a giochi di luce, lampade e lampadine, che si accendevano in sequenza secondo l’intensità della pedalata. Grandi e piccoli si sono alternati ai pedali e hanno potuto misurare l'energia elettrica prodotta.

On Saturday March 2nd the permanent experiment “Forza, pedala” showing the conversion of mechanical power into electric power, by bike generators, has been opened.

Bike generator are bycicles provided with an electric generator attached to the back wheel. By pedalling the kinetic power is transferred to the generator which convert it in clean electric power.

Three bikes have been installed and various lamp produced different light according to the strength of pedalling. Adults and children have enjoyed the experiment and could measure the power produced.

Pubblicazioni del Centro Interdipartimentale di Ricerca per la Storia della Tecnica Elettrica (CIRSTE)

Publications of the Research Centre

2013

SAVINI A. (ed.):

Un anno al Museo 2011 / Museum Year 2011

Pavia University Press, Pavia, 2013, ISBN 978-88-96764-42-8.

Museum Year 2011 describes the activities carried out in the Pavia Museum of Electrical Technology in 2011. It includes, in particular, the full Annual Lecture delivered by S. Jeszenski "From lightning to high voltage technology" and a description of a temporary exhibition on the history of personal computers. The main acquisition of the Museum in the year are reported as well.

SAVINI A. (ed.):

Un anno al Museo 2012 / Museum Year 2012

Pavia University Press, Pavia, 2013, ISBN 978-88-96764-43-5.

Museum Year 2012 reports about HISTELCON 2012, the IEEE International Conference on the origin of the electrotechnology, the main event hosted by Pavia Museum in 2012. Other events and a summary of the Annual Lecture delivered by P. Brenni on "Lightning under control" are included. New acquisition of the Museum and the list of the publications of the Research Centre are also reported.