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Disenchanted Night

The Industrialization of Light in the Nineteenth Century

Translated from the German by
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The University of California Press
Berkeley / Los Angeles / London

modernisation. Technically, it was nothing but an Argand burner. But the 'modern' fuel it used increased its illuminating power to such an extent that for a long time it was competitive with gas and even electric light.

In all these cases the old technology was infiltrated, as it were, by elements of a new technology. While the old technical principle was retained, new materials and processes did the work of modernisation. As always when new wine is filled into old bottles, however, the victory of the new technology could not be put off for ever.

Electrical Apotheosis

> The sunlight poured upon the rank vegetation of the carboniferous forests, was gathered and stored up, and has been waiting through the ages to be converted again into light. The latent force accumulated during the primeval days, and garnered up in the coal beds, is converted, after passing in the steam-engine through the phases of chemical, molecular and mechanical force, into electricity, which only waits the touch of the inventor's genius to flash out into a million domestic suns to illuminate a myriad homes.
> (Francis R. Upton, 1880)

Gaslight seemed to be the lighting of infinite possibility, so long as its brightness could be increased easily and at will. But it soon became apparent that there was a catch — gaslight consumed enormous amounts of oxygen. Up to a certain point, of course, ventilation could replace the air used up and heated by the ever larger and ever more numerous gas flames. But in the long run it was obvious that gas lighting had struck a natural barrier. This first became clear in the theatre — the place with the greatest appetite for light in the nineteenth century. Visiting the theatre often gave people headaches, not because of the performance but because of the air: 'We all of us know that the times when we suffer most from the effect of artificial light is in crowded

places of public amusement, which are at the same time brilliantly lighted. Many of us are unable to go to the theatre or to attend evening performances of any kind, as the intense headache which invariably attends or follows our stay in such places entirely prevents them.'[84] During a night at the theatre, the temperature measured under the ceiling of the auditorium could rise from 60 °F to 100 °F (15 °C to 38 °C).[85] While the increase was less extreme in the stalls and lower balconies, it remained uncomfortable enough. Private houses suffered similar conditions: 'When we take the library ladder to get a book from the upper shelf we find our head and shoulders plunged in a temperature like that of a furnace, producing giddiness and general malaise.'[86]

The deterioration in the quality of the air not only caused headaches and sweating, it also had an unpleasant effect on the interior decoration of rooms. As it burned, gas gave off small quantities of ammonia and sulphur, as well as carbon dioxide and water. At the beginning of the nineteenth century, gaslight had been celebrated as cleanliness and purity incarnate. Seventy years later the same gaslight seemed dirty and unhygienic — something that would inexorably destroy the most beautiful decorations:

> Everyone is familiar with the luxuriousness of public rooms, which vie with each other in opulence and elegance in order to make a visit there comfortable. Paintings, sculpture and architecture compete with fantastic and graceful figures and allegories in embellishing walls, friezes and ceilings. . . . Some time later, however, the gas flames began their work of destruction. They blackened the ceilings and marked joins in the gilding; most surfaces turned yellow and oil paintings almost disappeared or were darkened by smoke.[87]
>
> The discolouration or darkening of paintings and the dulling of metal decorations an also be attributed to the effects of the combustion products of gas.[88]

84. R.E.B. Crompton, *Artificial Lighting in Relation to Health, A Paper Read at Conference Held at the International Health Exhibition, South Kensington* (London, n.d. [1881]), p. 9.
85. Ibid., p. 7.
86. Ibid., p. 6.
87. *L'Evénement*, 23 October 1881, quoted from *Das Edisonlicht. Elektrisches Beleuchtungssystem* (Berlin, 1882), pp. 62–3.
88. Alfred von Urbanitzky, *Die elektrischen Beleuchtungsanlagen* (Vienna/Pest/Leipzig, 1883), p. 119.

Where gaslight failed, electric light took over, repeating at a higher technical level what gaslight had achieved in its time. Gaslight represented progress over candles and oil-lamps in that it did away with the wick; electric light went one step further and abolished the flame. Electric light did not use up oxygen, and left the chemical composition of the air unchanged. Unlike gaslight, it could really be intensified at will.

Before these qualities were perfected in the electric light bulb, electrical technology bred a hybrid which provides another illustration of how gradually technology changes. The transition from an open gas flame to the closed electric bulb was made by open electrical incandescent lighting.

Arc Lighting

The pioneer of electro-chemistry, Humphry Davy, was the first to observe the light produced by a discharge of electric current between two carbon electrodes. This took place in 1800, and here is how he described the phenomenon twelve years later: 'When pieces of charcoal, about an inch long and one-sixth of an inch in diameter, were brought near each other (within the thirtieth or fortieth part of an inch), a bright spark was produced . . . , and by which drawing the points from each other a constant discharge took place through the heated air, in a space at least equal to four inches, producing a most brilliant ascending arch of light.'[89]

Arc lighting, as it has been called since Davy, is not produced primarily by the electric arc itself, as was first assumed. It is caused mainly by the electric charge heating the carbon electrodes to white heat. In this respect, arc lighting is in fact incandescent lighting. At the same time, however, it is also produced by combustion, as the carbon particles actually smoulder in the surrounding air. Unlike incandescent light enclosed in

89. Humphry Davy, *Elements of Chemical Philosophy* (London, 1812), Vol. 1, p. 152. Davy, incidentally, was not the only person to produce an 'arch of light' at that time. During the first ten years of the nineteenth century many researchers were conducting experiments with the voltaic pile, in the course of which they observed the discharge of an arc of light (Walter Biegon von Czudnochowski, *Das elektrische Bogenlicht. Seine Entwicklung und seine physikalischen Grundlagen*, Leipzig, 1904, pp. 4ff).

Jablochkov Candle.
A form of electric arc lighting in general use in the 1870s, featuring a peculiar combination of old and new technology. The two carbon rods were separated by an insulating layer of gypsum and, when the electric arc had been 'lit', burned down in about one and a half hours.
(*Source*: A. Bernstein, *Die elektrische Beleuchtung*, Berlin, 1880.)

an airtight container, open arc lighting 'burns' at the electrodes, consuming them as the candle flame consumes the wax shaft. An arc lighting installation in general use in the 1870s functioned quite literally in this way. In the Jablochkov Candle, named after its Russian inventor, the electrodes took the form of two parallel carbon rods separated by an insulating layer of gypsum. The top was lit and the candle burned down slowly until the carbon rods were consumed, whereupon the light went out, as in the traditional candle. Placing the electrodes in a vacuum put an end to this electric combustion. In the closed arc-lamp, they were hermetically sealed in glass. The only way in which the arc lamp differed from later incandescent lighting was that the light emanated from white hot electrodes rather than from a filament.

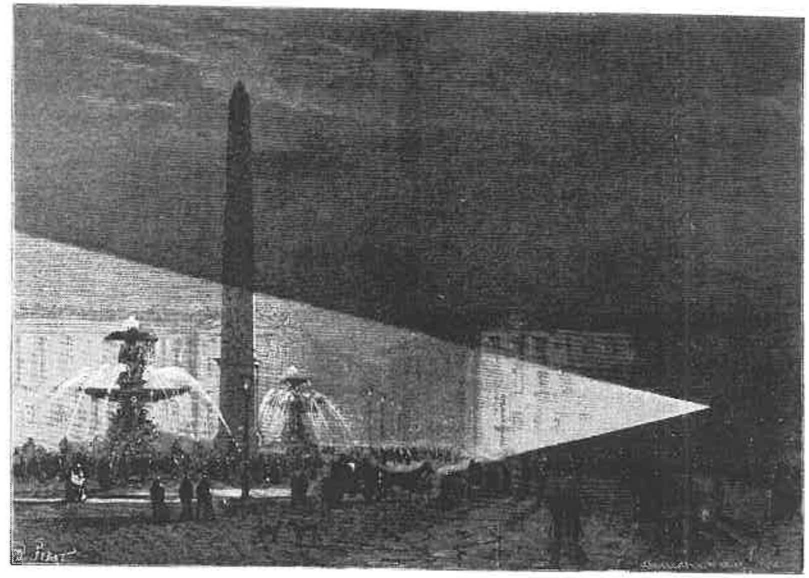
It took a surprisingly long time for more general applications to be found for arc lighting. More than forty years passed before it was used outside the laboratory and even then it was used only sporadically — for special effects in the theatre, or large-scale festive illuminations. Not until 1870 was it firmly enough established to become part of the general lighting scene.

Initially, development was slow because of purely technical factors. Arc lighting as Davy developed it had no practical uses until three prerequisites were met. Firstly, a mechanism was needed to keep the gap between the electrodes equal as they burned down. The first regulators that did this job were constructed in the 1840s; the problem was finally solved in 1878 when Hefner-Alteneck, who worked with Siemens, developed the differential regulator.

Secondly, the electricity supply had to be improved. Volta's battery, although much improved after 1830 by Danniell, Grove and Bunsen, could not cope in the long term. The dynamos constructed by Gramme and Siemens in 1867 made it possible for the first time to produce large amounts of electricity continuously.

Thirdly, the electrodes had to be made of better material. Simple charcoal, which Davy used, burned too irregularly and, above all, too quickly. The synthetic carbon rods in use from 1840 smouldered very slowly and emitted a bright, even light.

As a result of these technical improvements, arc lighting was fully operational by the 1870s. But in practice, its use was limited to factories, shops, railway stations, building sites, wharves and so on — in short, to large spaces with an insatiable appetite for light. It was simply too intense for use in other places, such as houses. Arc lighting was the first artificial source that produced too much light for many purposes. Unlike all earlier innovations in lighting which had been metaphorically compared to the sun, arc lighting really did resemble sunlight, as spectrum analysis shows. As bright as daylight, arc-light overwhelmed people when they experienced it for the first time. It was as though the sun had suddenly risen in the middle of the night. In 1855 the engineers Lacassagne and Thiers staged an experiment with their arc lighting system in Lyon. The *Gazette de France* reported the event in the following terms:

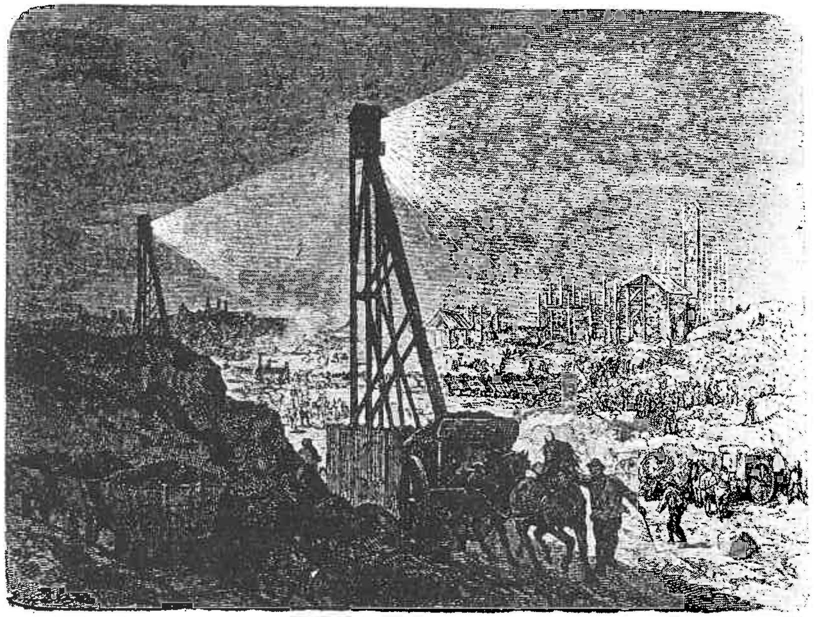


Arc lighting in the Place de la Concorde (1844).
'The light, which flooded a large area, was so strong that ladies opened up their umbrellas — not as a tribute to the inventors, but in order to protect themselves from the rays of this mysterious new sun' (newspaper report).
(*Source*: *La Lumière électrique*, 1883)

> Strollers out near the Chateau Beaujou yesterday evening at about 9 p.m. suddenly found themselves bathed in a flood of light that was as bright as the sun. One could in fact have believed that the sun had risen. This illusion was so strong that birds, woken out of their sleep, began singing in the artificial daylight. . . . The light, which flooded a large area, was so strong that ladies opened up their umbrellas — not as a tribute to the inventors, but in order to protect themselves from the rays of this mysterious new sun.[90]

Arc-light was measured in thousands of candle powers, whereas gaslight was at best reckoned in dozens. Concentrated in a floodlight, arc-light could light up military targets at distances of up to six kilometres. Next to its intensity, its absolute

90. J. Lacassagne and R. Thiers, *Nouveau système d'éclairage électrique* (Paris and Lyon, 1857), p. 25.

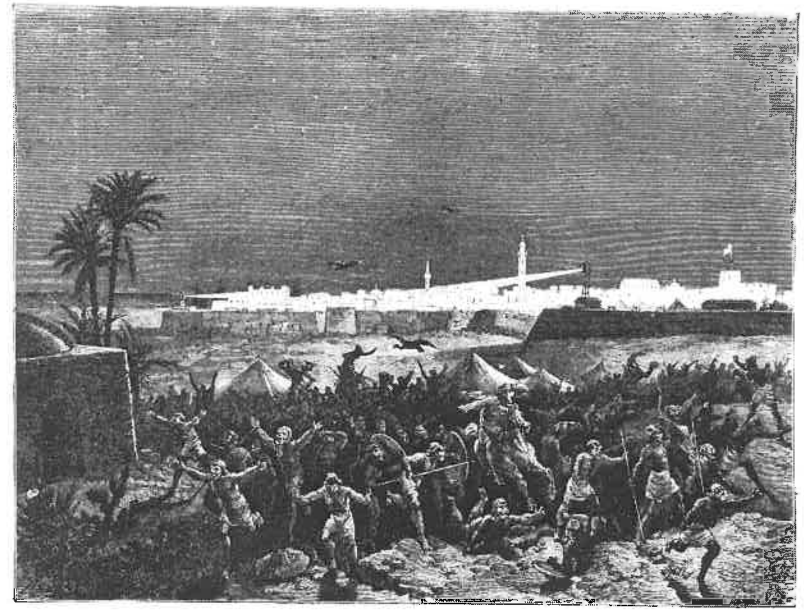


Large building-site under arc-lights.
(*Source*: Fontaine, *Éclairage à l'électricité*)

steadiness was the most striking thing about arc lighting. The *Gazette de Lyon* wrote about Lacassagne's and Thiers' experiment: 'Like everyone else we, too, were surprised by the brightness of this light. The thing that impressed us most, however, was its evenness, its unchanging quality, its absolute steadiness.'[91]

Though these qualities undoubtedly made arc lighting the most modern form of illumination of its day, it was a technological step backwards from gaslight. Arc-light was, in nineteenth-century terminology, indivisible; that is, its intensity could not be varied. Nor was there a central supply system that could serve many lights at once. Every arc light had its own separate battery. Like the candle and the oil lamp, arc lighting was governed by the pre-industrial principle of a self-sufficient supply.

91. 19 June 1855, quoted from ibid., p. 19.



Arc lighting and the colonial wars (1884).
'When the rebels were only a few hundred metres away and had begun to attack, the electric floodlights suddenly blazed into action, bathing them in the most brilliant light. The surprise and confusion were so complete that they defy description' (report on the use of arc lighting in the Sudan).
(*Source*: *La Lumière électrique*, 1884.)

Before electric light could serve as a general source of illumination suitable also for use in private houses, these disadvantage of arc lighting had to be overcome. The next move was obviously to appropriate the technical achievements of gas lighting — its adjustability and central supply — in a reversal of the process, described above, by which old technologies imitate new ones. On closer inspection, Edison's incandescent electric light is, in fact, nothing but a methodical imitation of gaslight in a new medium.

The Electric Bulb

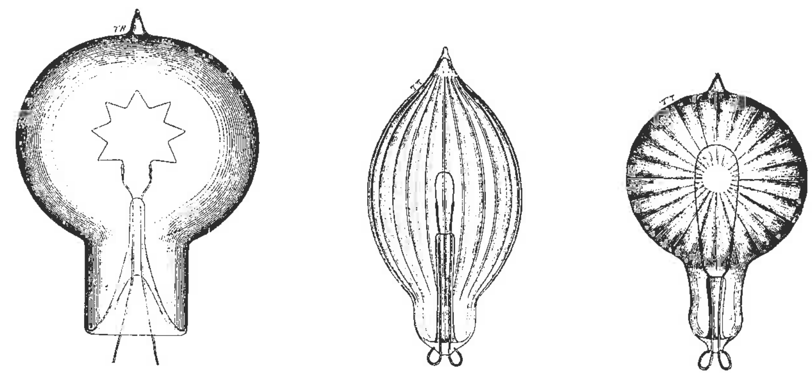
Edison's 1879 experiment with incandescent electricity, lasting more than forty hours, was not the world's first glimpse of this type of lighting. During his experiments early in the nineteenth century, Davy had already observed that a wire — in this case platinum — carrying an electric current heats up evenly and eventually begins to glow. Nor did Edison discover that placing the wire in a vacuum prevented it from burning away. Frederick De Moleyn, an Englishman, had achieved this in 1841. And finally, the trial that Heinrich Göbel, an American inventor of German descent, conducted against Edison established that the carbon filament lamp Göbel had constructed as early as in the 1850s 'had been a truly serviceable source of light, and that Göbel had thus been using a practical incandescent lamp, and had shown it in public, twenty or thirty years before Edison'.[92]

Edison is important not because of an isolated invention but because he perfected existing elements and combined them in an operational technical unit. He also had a great gift for publicity. (In this respect, he can be compared to Winsor, the pioneer of gas lighting. On the other hand, Edison's great technical gift separates him from Winsor.)

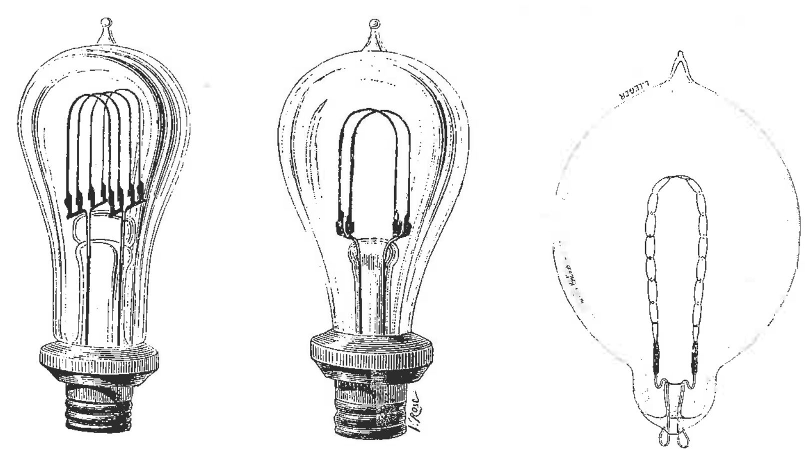
Edison began his work on the technology of lighting with the declared aim of producing an incandescent light that shared all the advantages of gaslight without using up the air. His notebooks contain the following entries: 'Edison's great effort — not to make a large light or blinding light, but a small light having the mildness of gas'; 'Object, Edison to effect exact imitation of all done by gas, so as to replace lighting by gas by lighting by electricity.'[93]

Edison's carbon filament lamp, put together in 1879 and made public at the Paris Electricity Exposition two years later, was instantly hailed as a successful imitation of gaslight. For the first time, progress was made not by increasing the intensity of light but by imitating existing levels using new technology. An advertising brochure issued by Edison states that 'the light given out by the lamp resembles gaslight in colour and intensity, but

92. Artur Fürst, *Das elektrische Licht* (Munich, 1926), p. 124.
93. George S. Bryan, *Edison: The Man and His Work* (London and New York, 1926), p. 111.



Early electric light bulbs and filaments.
Initially, the only way to make electric light brighter was to increase the number of filaments. The imagination was totally free to devise interesting shapes for filaments and bulbs. Can we see this playfulness as an attempt to compensate for the uniformity of electric light?
(*Source*: *La Lumière électrique*, 1881, 1886)



differs from it in that it is absolutely even and steady'.[94] All independent observers confirmed this claim. For example, a French report of the 1881 Paris Electricity Exposition made the following points:

> We normally imagine electric light to be a blindingly bright light, whose harshness hurts the eyes. . . . Here, however, we have a light source that has somehow been civilised and adapted to our needs. Every individual light shines like gaslight, but this is a type of gas that has not yet been invented — a gas that gives a completely steady light but nevertheless shines vividly and brightly and places no strain on the retina. But then — how different from gas! Electric light leaves no combustion residues in the house — no carbon dioxide and carbon monoxide to pollute the air, no sulphuric acid and ammonia to damage paintings and fabrics. Electricity does not raise the air temperature, and does not give off the uncomfortable and fatiguing warmth associated with gas lighting. It puts an end to the danger of explosion or fire. It is not affected by fluctuations in the outside temperature or changes in mains pressure. . . . It shines evenly and steadily, irrespective of the season . . . and in water as well as in air. It is totally independent of all external influences.[95]

The popular magazine *Die Gartenlaube* carried a report of the Exposition listing the same qualities, and saw the electric light bulb quite literally as a reduced version of the arc-light: 'There is no flickering and not the slightest noise; drawing rooms are not heated up — there is only the most extraordinarily pleasant, pure air; added to this is the comfortable, lively colour of the small arc-light [*sic*]: truly, this must be almost the "ideal form of illumination".'[96]

One factor in bringing the light of the early electric bulbs to roughly the same intensity and quality as gaslight (by today's standards it was a little weaker than that of a twenty-five watt bulb[97]) was the material used for the filament. The *carbon* filament in general use until the late 1890s represented a link between electric light and older lighting technologies, all of which were based on the combustion of carbon rods. In the nineteenth-century psychology of light, it was important to

94. *Das Edisonlicht*, p. 14.
95. Henry de Parville, *L'Electricité et ses applications*, 2nd edn (Paris, 1883) pp. 354–5.
96. Quoted from *Das Edisonlicht*, p. 71.
97. Terence Rees, *Theatre Lighting in the Age of Gas* (London, 1978), p. 171.

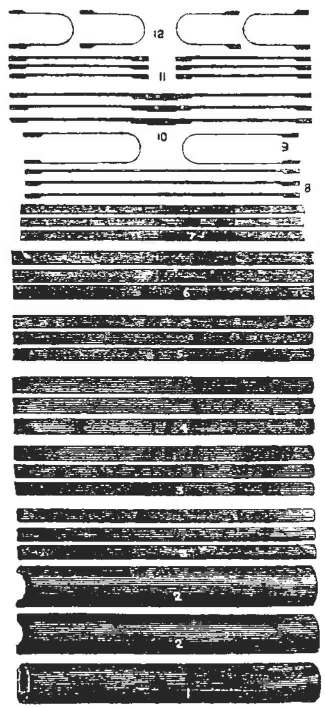
establish this continuity, as it allowed people to see the old in the new, and thus the new as something familiar. 'Since . . . the luminosity of the coal gas flame is due to incandescing particles of carbon set free in the flame, and which are subsequently burnt up, and the light of the electric incandescent lamp consists of incandescent rays emitted by the carbon filament which is heated by the electric current, it follows that the nature and character of the light from both are the same.'[98]

In quality, gaslight and electric light were almost interchangeable, but an examination of the light source itself soon revealed the differences between them. The filament's surface was only a fraction of the size of a flame; it therefore had to glow much more brightly in order to cast the same amount of light. Everyday perceptions, still geared towards the gas flame, had to be trained to see the filament at all. 'Born and educated in the use of illuminants which present to the eye a soft wide gaseous flame, having a measurable irridescent surface containing incandescent particles widely dispersed, we were quite unprepared to estimate the increased power of the brilliant little line of intense incandescence that meets our view when we regard this glow lamp.'[99]

We will describe the impact which the substitution of filament for flame had on perceptions in a later chapter ('The Drawing-room', p. 167f.). In the meantime, looking at the filament's progress allows us to follow the physical microstructure of the modernisation process. The eye would have to come to terms with its results.

With filaments made of carbonised plant fibres, the electric bulb had an organic basis. The structure of the fibres determined the quality of the light that was produced. A description dating from 1890 of the process by which electric bulbs were manufactured points out how important it is that 'the structure of the wood [*sic*] has not been destroyed by fungi or rot. In one case a factory could not turn out a single good lamp for a whole week because it had been supplied with rotten bamboo from China.'[100] The structure of the carbonised paper that Edison had

98. *Lancet*, vol. 1 (1895), p. 52.
99. *Electrical Engineer*, December 1886, p. 261.
100. J. Zacharias, *Die Glühlampe, ihre Herstellung und Anwendung in der Praxis* (Vienna, Pest and Leipzig, 1890), pp. 18–19.



From bamboo to filament.
The illustration shows the gradual transformation of nature into technology. The particular bamboo that, after many years of searching, Edison had selected as the most suitable for his purpose was split repeatedly to separate it into fine fibres, which were carbonised and then bent into the shape of a filament.
(*Source*: *L'Electricité*, 1882)

used in his first experiments proved to be unsuitable:

> The very short fibres that make up paper are arranged in many irregular layers. The current therefore cannot find an even path through the filament, but has constantly to surmount changing obstacles. There are also countless spots where the current can only continue on its way by crossing very narrow air pockets embedded in the structure of the paper, with the result that extremely fine sparks are created. These contribute to the rapid disintengration of the filament.[101]

Looking for a suitable fibre, Edison carbonised almost 6,000 vegetable substances. He started with everyday materials such as paper, yarn, cork, celluloid, linen, wood, and human and animal hair,[102] and discovered that bamboo fibre was particularly well suited to his purpose. An international search for the optimal bamboo fibre followed, in the course of which Edison's assistants combed the jungles of South America and the wastelands of China. Eventually, they discovered a species of bamboo with especially long and regular fibres in Japan. Edison concluded a supply agreement with a Japanese planter, and thus was created a bamboo plantation whose sole purpose was to cultivate material for the production of filaments.[103]

This step represents the peak of the rationalisation of organic fibre. It was succeeded by the fibreless, synthetic filament, whose production involved a completely new process. The material used first was cellulose which, 'in the form of a quick-setting paste, was forced through nozzles to produce an endless thread of absolutely regular diameter. It was wound on to a spool and then cut into the required lengths.'[104] The metal alloys that followed a little later were produced by the same method. In a further example of the interaction between old and new technologies, the first practical metal filament lamp — the osmium lamp — was constructed in 1898 by Auer von Welsbach, who a few years earlier had so successfully 'transferred' the technology of electric incandescent lighting to gas in creating incandescent gaslight. The knowledge of materials that he developed in the process, or rather, that made his discovery possible in the first place, now proved amenable to a 'counter-transference' back to electric light, completing the circle of mutual influence.

In the 1890s all sorts of metal alloys were used for filaments, each one producing a brighter light than the last. This is how the

101. Fürst, *Das elektrische Licht*, p. 95.
102. Bryan, *Edison*, p. 127.
103. Ibid., pp. 133–4.
104. Fürst, *Das elektrische Licht*, p. 128.

electric light industry tried to combat the competition of gas incandescent lighting. Eventually, just before the First World War, the tungsten filament was developed. This perfected incandescent lighting, which finally realised its full range, from a weak reddish glow right through to the blinding white light of a modern 300-watt light bulb. Edison's carbon filament lamp belonged to the nineteenth century because it was no brighter than a gas flame. The tungsten lamp, however, betrayed no hint of this origin. Twentieth-century illumination had begun.

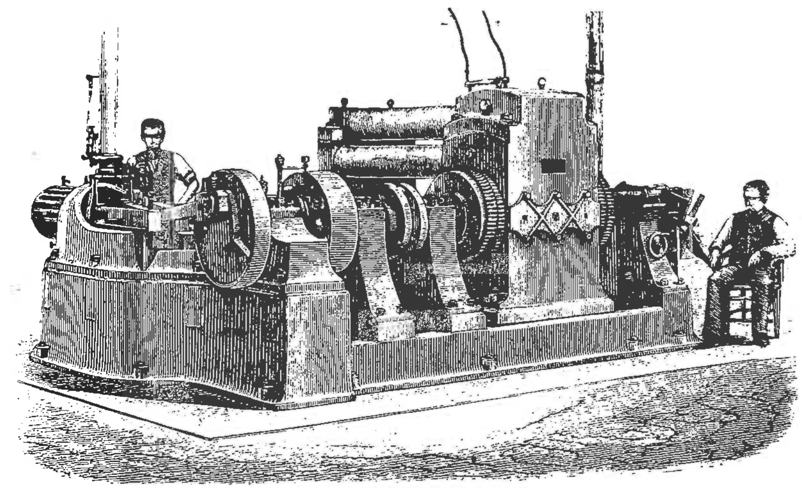
Electrification

Light intensity and quality were not the only ways in which the Edison lamp copied gaslight. In other essential aspects, too, it was modelled on its predecessor — most significantly in the transferral of the idea of a central supply. Arc lighting had been able to dispense with this as it was suitable only for large public rooms and spaces, which could accommodate their own generators without difficulty. This situation changed the moment the electric bulb turned electric light into a form of illumination that could be used everywhere. As it was impractical to provide a generator for every private house, a central supply modelled on the gas supply was an obvious solution. In 1880, when the electric bulb was available but a central supply of electricity was not, the situation was described as follows:

> We city dwellers can have gas supplied to our house, ready for use. We turn on a tap, hold a lighted match to the mouth of the pipe and that is the end of our efforts to obtain a light. We turn off the tap and the light goes out. This is extremely convenient — one is tempted to say, seductively convenient. Electric light is a different matter; we have to generate our own electricity, as there is no company yet that supplies it.[105]

Edison developed the central electricity station on the model of the gas-works just as seventy years earlier Winsor had conceived a central gas supply along the lines of the water supply.

105. Alex Bernstein, *Die elektrische Beleuchtung* (Berlin, 1880), p. 61.

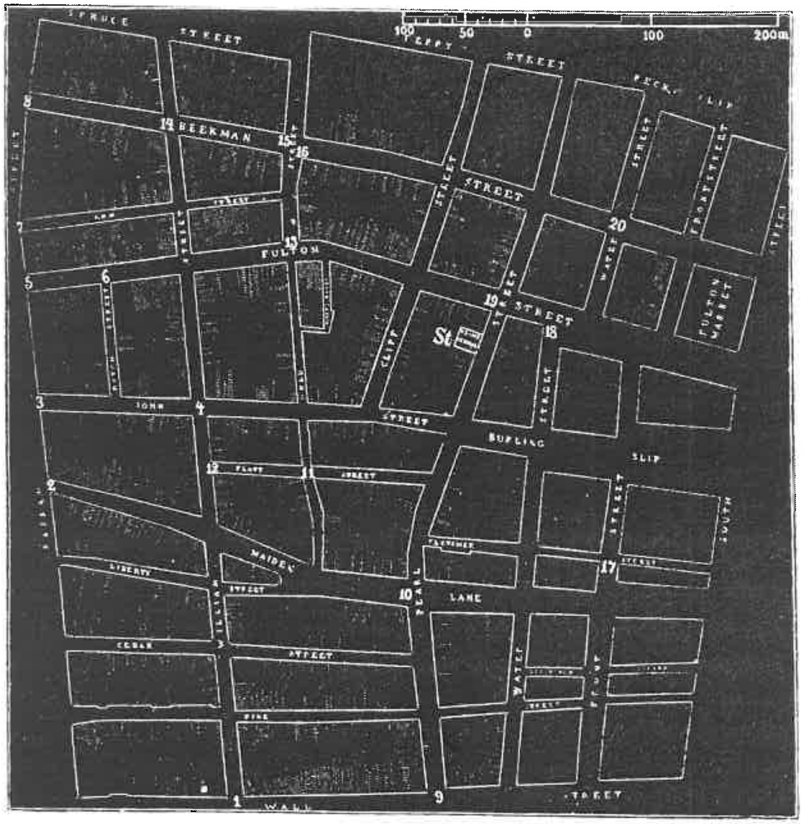


Edison's dynamo (1881).
(*Source*: A. Fürst, *Das elektrische Licht*, 1926)

The first central electricity stations became operational in 1882 in London and New York. A French writer, describing them one year later for readers who were unfamiliar with the subject, presents them as electrified gas-works:

> The gas supply, which on the basis of long experience offers itself as a model, functions as follows: one or more gas-works are built in every city, according to the size of the area to be supplied. Correspondingly, the American inventor [Edison] plans to set up one or more electricity generating stations, according to the size of the area. Gas is conveyed underground through large pipes, which follow the main transport routes; from this network of mains, smaller pipes lead off into the side streets, and even smaller supply pipes branch off from these, taking the gas into individual houses. This type of supply system has been adopted for the distribution of electricity. Mains go out from every central electricity station, these branch out into secondary cables and from these in turn supply cables lead off to individual houses. Electric cables resemble gas pipes except that they have a much smaller diameter. The largest is no thicker than an arm.[106]

106. de Parville, *L'Electricité*, pp. 375–6.



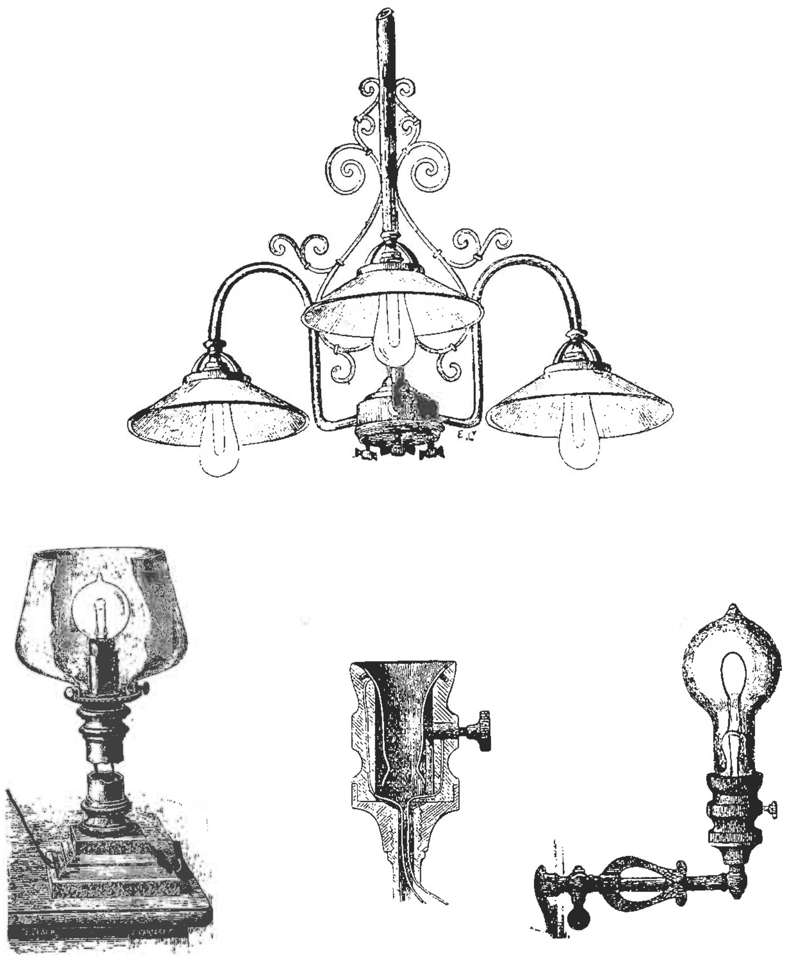
Area supplied by the first central electricity station, New York, 1883. Consumers are shown as bright dots; the location of the station is indicated by the letters 'St'.
(*Source*: Fürst, *Das elektrische Licht*)

Of course, the days of electricity imitating the gas supply were numbered. When it became apparent that high-voltage current could be transported over long distances without an appreciable loss of voltage, it took only a few years to develop a new system that evoked no memories of gas-works. Central electricity stations were replaced by power stations built not in the cities they supplied but in areas where the energy required to generate electricity was cheapest. The new locations — in coal-mining districts, near waterfalls or dams — were often hundreds of kilometres away from where the electricity was used. (The first

significant overhead transmission line, which became operational in 1891 and linked a power station at Lauffen on the Neckar with Frankfurt on Main, was 179 kilometres long.) Modern, high-capacity power stations no longer supply a single town, but a whole region. The consequences of this centralisation are most obvious when the electricity supply fails. A blackout paralyses a whole region as quickly as the prick of a spindle sends the whole palace to sleep in the fairy tale of the Sleeping Beauty. As with the method of electricity supply, the first electric light switches were also modelled on gas lighting. 'Every arm of a chandelier and every lamp has a revolving switch, reminiscent of a gas tap. When it is operated, the electrical circuit between the bulb and the underground cable is closed and the light burns. The opposite action breaks the circuit and the light goes out. If the house has no electricity, there is no light either.'[107] The electric *switch* is progress over the gas-*tap* in that it is turned on and off in one movement. Unlike gaslight that had to be physically lit — 'One turns on the tap, lights a match and the light flares up'[108] — and then began to burn with the leisureliness of a candle flame, electric light comes on in an instant: 'You come home, turn on the switch, and without fire, without a match, the whole house lights up.'[109] The novelty of switches stimulated people's imagination; as we can see, in the above example it is not simply one room, but the whole house that is suddenly bathed in light. And the author immediately goes on to describe a lighting system that switches itself on and off automatically: 'Is it too much trouble to press a button or operate a revolving switch? Well then, you open the door of your hall, and the light goes on by itself. You enter the living room, and the lights are on. . . . Similarly, the light turns itself on automatically when you enter the bedroom or the study. Simply by opening a door, you cause the light to come on in the room.'[110]

For obvious reasons, this vision never became reality. What eventually happened was that the light switch was placed next to the door, allowing people to choose whether they wanted to

107. Ibid.
108. Ibid., p. 355.
109. Ibid.
110. Ibid., pp. 355–6.



Early light switches. The light switch's origins in the gas-tap remained clearly visible for many years. Early electric switches were *turned*, and they were placed on each individual light. Actual switches and the ability to turn lights on at a distance are much later developments.
(*Source*: A. Fürst in *La Lumière électrique*)

enter a room in darkness or in light. (This naturally also had the advantage that the door of a room could be shut without the light turning itself off automatically.)

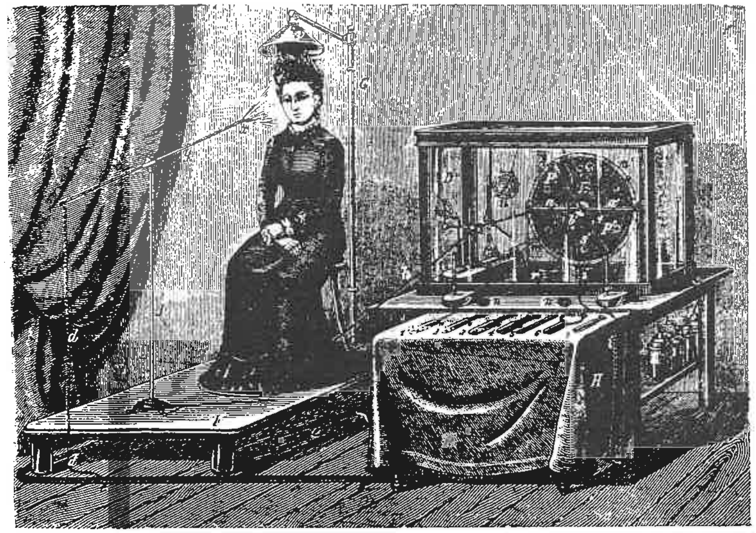
The fact that electric light could be switched on and off instantly was recognised as a fundamentally new property compared with gaslight. Nevertheless, the earliest form of electric switch, the *revolving switch*, was nothing but an imitation of a gas-tap: contact was established *gradually*, as though it were a matter of regulating a gas supply, not closing an electrical circuit. The revolving switch was unsuitable for electricity because, as was discovered retrospectively, in 1926, 'it switched off the current too slowly — not instantly through spring action. Disconnection was determined by the speed with which the switch was turned.'[111]

The examples of a central electricity supply and the light switch show how varied the results can be when a new technology borrows from an older one. While the central electricity station modelled on the gas-works perfected electrical technology, the revolving switch, an imitation of the gas-tap, was a backwards step. As this chapter has shown, the interplay of mimicry between old and new technologies is riddled with such contradictory results. But in the end, developmental mistakes are always corrected. The electrical revolving switch, for example, was soon replaced by the spring action quick-break switch which is still used for electric lights today.

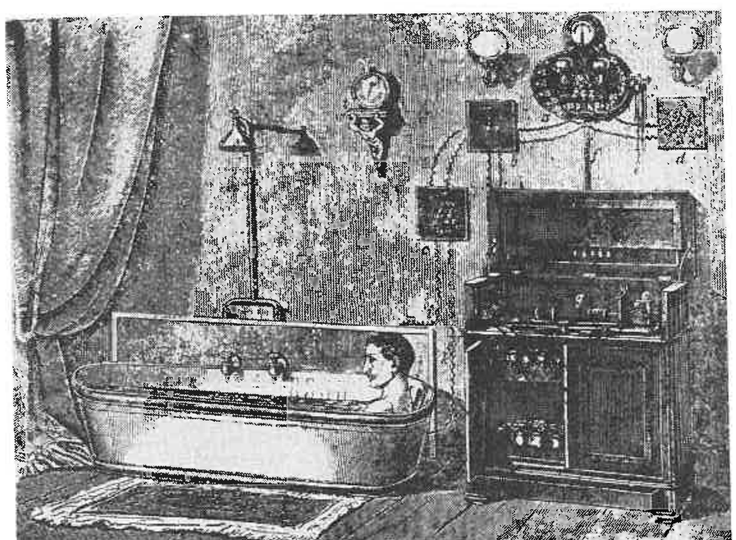
The enthusiasm with which electric light was hailed in the late nineteenth century is in many respects reminiscent of the reaction evoked by gas lighting seventy years earlier. In their time, both innovations were regarded as the most modern, the brightest, cleanest and most economical form of lighting; in both cases, their industrial nature was obvious; and finally, electric light seemed to be nothing other than an imitation of the system of gas lighting.

There were, however, also important differences between them. While the bourgeois household was reluctant to admit gas because of its unpleasant smell and its poisonous, explosive

111. Fürst, *Das elektrische Licht*, p. 102.



Electricity and health: electrification.
(*Source*: *L'Electricité*, 1882)



Electricity and health: an electric bath.
(*Source*: *L'Electricité*, 1882)

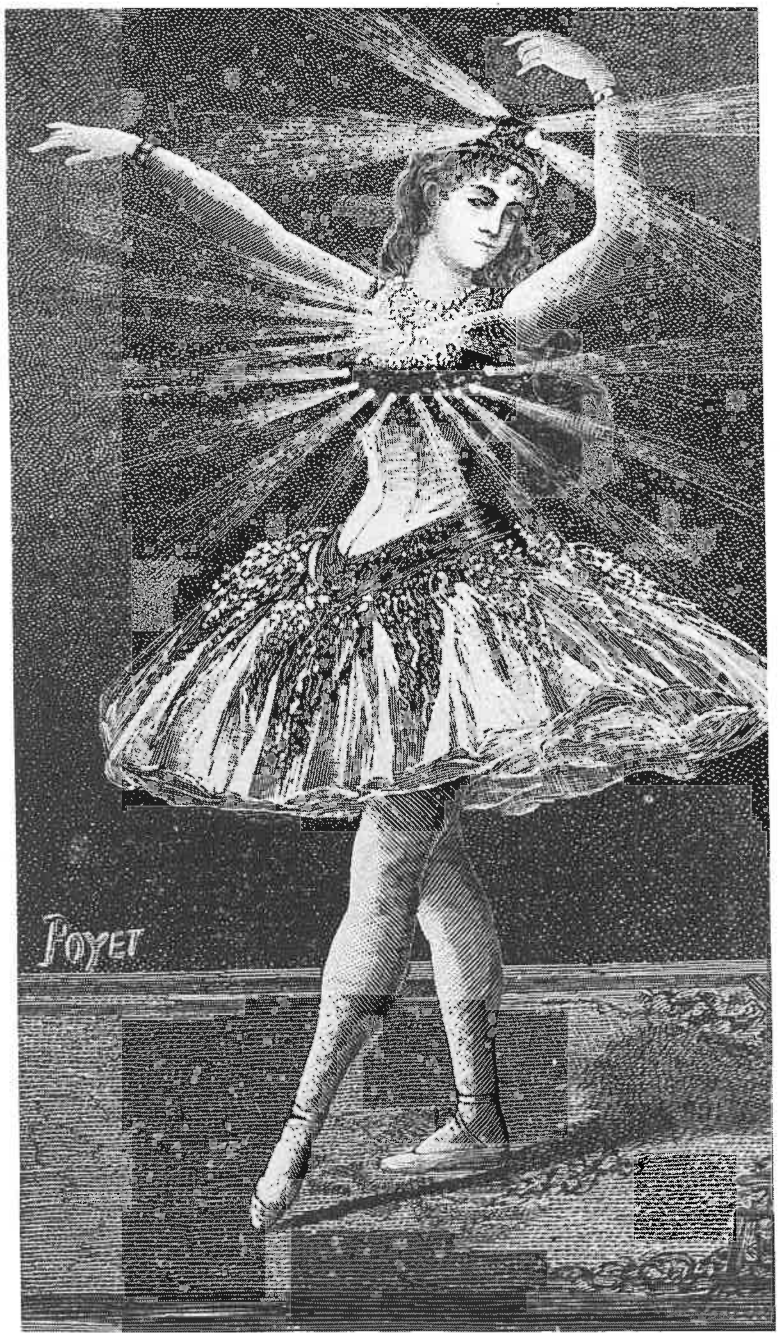
nature, all doors were immediately opened to electric light: 'The Edison light is penetrating not only into rooms that are at present lit by gas, but even into those that are closed to it — that is, elegant apartments and drawing-rooms — and replacing candles in chandeliers and candelabra.'[112] It was electricity's properties as a pure, odourless and non-physical form of energy that made it immediately acceptable in drawing-rooms. Electricity did not endanger life or health; on the contrary, it was regarded as positively beneficial,almost as a sort of vitamin. For the century of Hermann von Helmholtz, electricity, energy and life were synonymous. Electricity was believed to be, and was used as, a means of restoring exhausted energies. In a study of the late-nineteenth-century obsession with exhaustion, we read that 'in the chemical and technological warfare against fatigue one weapon stands out among the rest: electricity. If fatigue was the disorder of energy, electricity held out the promise of restitution.'[113] In agriculture, electrictity was used like a fertiliser. 'Electro-culture' consisted of 'galvanising' the land that was to be cultivated. Radishes and carrots that had been treated in this way 'had an exquisite flavour and were very tender and juicy', as a description of such experiments in the 1890s tells us.'The average yield of "galvanised" plants compared with those grown in the normal way is 4 : 1 for vegetables and root crops, and 3 : 2 for other crops.'[114] Medicine had been fascinated by electricity and magnetism since the end of the eighteenth century. Now it began to use available electrical technology to treat the body rather like 'electro-culture' was treating the soil. The spectrum of electro-therapy ranged from continuous galvanic current to electric-shock treatment.[115] A French patent application, made in 1882 and entitled 'Mode d'application de l'électricité, pour les vêtements, sur le corps humaine', proposed the following method of exposing the body to electricity: 'Two pockets, sewn on to the sides of the garment, each contain

112. *Journal des débats*, quoted from *Das Edisonlicht*, p. 59.

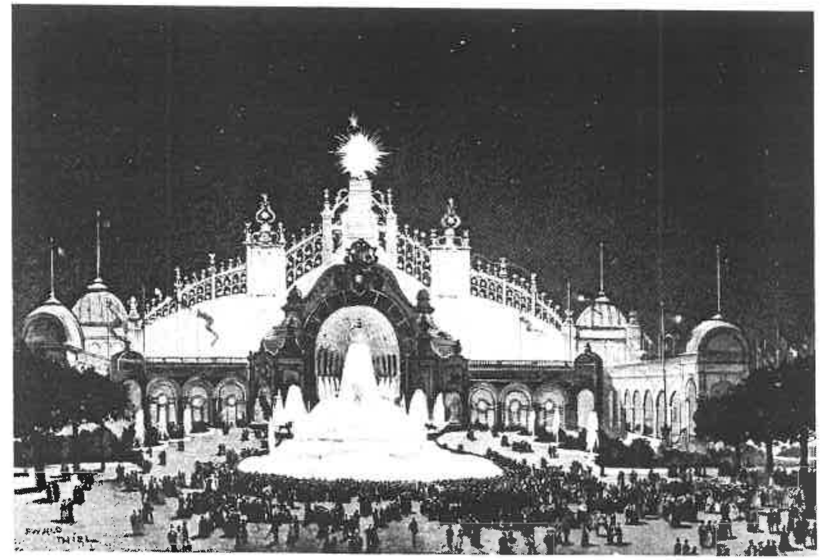
113. Anson Rabinbach, 'The Age of Exhaustion: Energy and Fatigue in the late 19th century' (unpublished manuscript), p. 38. (French translation published as 'L'Âge de la fatigue; énergie et fatigue à la fin du 19e siècle', *Urbi*, no. 2, December 1979, p. 46).

114. Alfred Ritter von Urbanitzky, *Die Elektrizität im Dienste der Menschheit* (Vienna, Pest and Leipzig, 1895), p. 353.

115. See George Beard, *Medical and Surgical Uses Of Electricity* (1874); see also Rabinbach manuscript, p. 39.



Electric jewels.
(*Source*: *L'Illustration*, 1881)

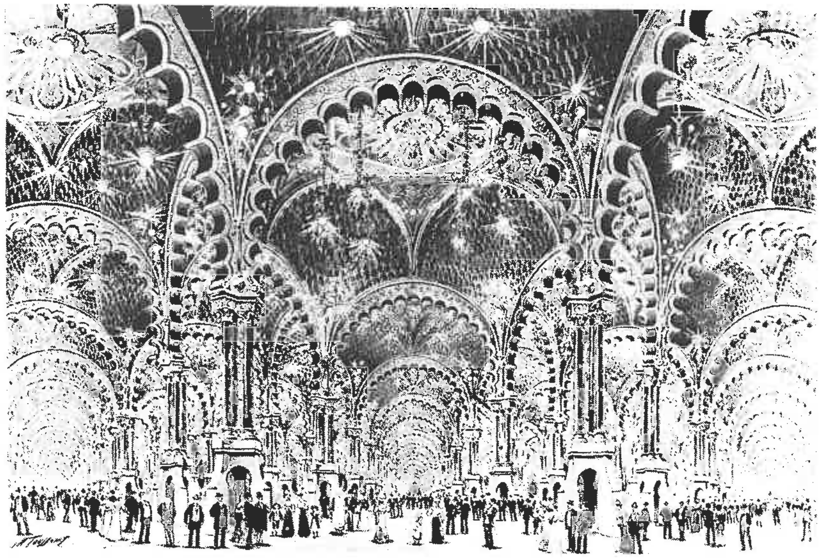


The Palace of Electricity at the Paris Exposition of 1900:
exterior view.
(Archiv für Kunst und Geschichte, Berlin)

a small battery. Two vertical metal bands are attached to the batteries, and from the bands, metal wires go out to all parts of the body. In order to allow electricity to flow through the body, the inventor has fastened small metal plates to the wires at certain intervals. These plates lie on the skin.'[116]

The practical applications of electricity were not limited to medicine, agriculture and illumination. Between 1880 and 1920 electricity began to permeate modern, urban life. Local traffic systems, lifts, the telephone, radio and cinema as well as a constantly growing number of household appliances would have been inconceivable without electricity. Electrical energy had the same impact on material culture as on the body. Ac-

116. Quoted from *La Lumière électrique*, vol. 9 (1883), p. 252. This type of electro-therapy naturally reminds us of the use of electricity as a means of execution. When the electric chair was first used in the United States in 1890, it was justified in terms of the scientific precision, painlessness and so on of death by electrocution. The French journal *Electricité* commented: 'La connaissance de la manière dont l'électricité donne la mort n'est-elle point indispensable pour savoir comment elle peut être utilisée à entretenir la vie?' (*Electicité*, 1890, p. 448).



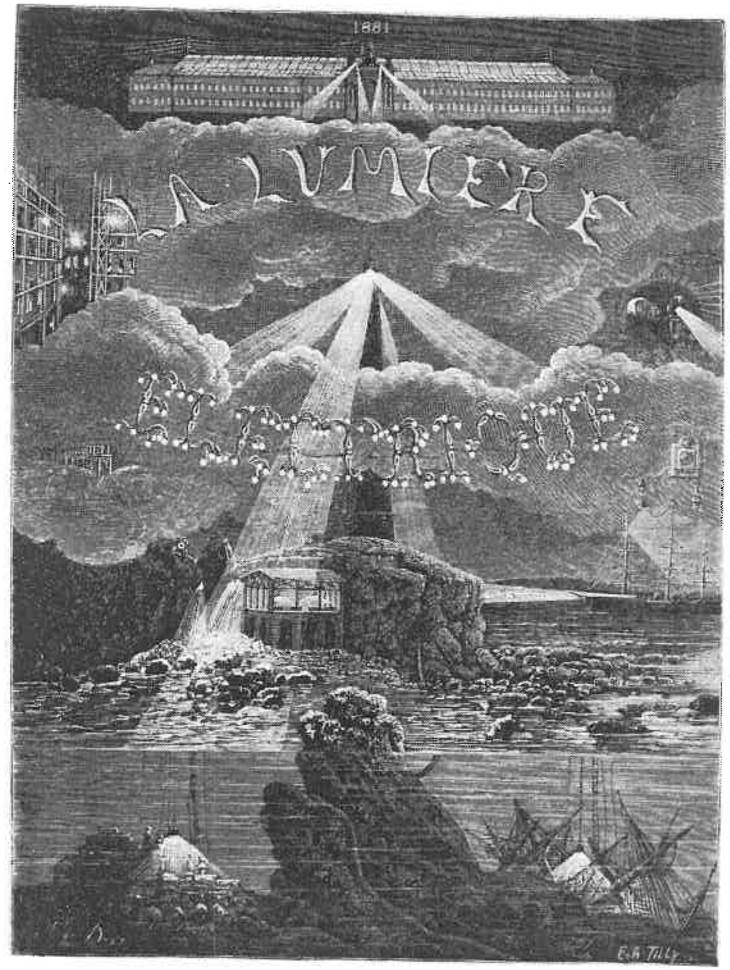
The Palace of Electricity: interior view.

cording to the *Scientific American* supplement of 7 March 1900, the general public believed that if there was anything under the sun that electricity could not do, then it was not worth doing.[117]

The period of electrification also witnessed changes in the economic structure of capitalism. The transformation of free competition into corporate monopoly capitalism confirmed in economic terms what electrification had anticipated technically: the end of individual enterprise and an autonomous energy supply. It is well known that the electrical industry was a significant factor in bringing about these changes. An analogy between electrical power and finance capital springs to mind. The concentration and centralisation of energy in high-capacity power stations corresponded to the concentration of economic power in the big banks. Werner Sombart wrote: 'Production and distribution, trade and commerce are becoming more and more dependent on banks and stock exchanges'.[118] To cling to entre-

117. *Scientific American*, 7 March 1900 (Supplement).

118. Werner Sombart, *Die deutsche Volkswirtschaft im 19. Jahrhundert und im Anfang des 20. Jahrhunderts* (Stuttgart, 1954; reprint of the 7th edn), p. 200.



The Apotheosis of Electricity.
Title page of the journal, *La Lumière électrique*, 1882

preneurial autonomy and energy independence in the new world of the second Industrial Revolution would have been a quixotic act. The new industries, electricity and chemicals, were the breeding ground of the new faith in technical, scientific and politico-economic planning that emerged after about 1900. The engineers who increasingly replaced entrepreneurs in these industries completed the transition from technical to economic reality. 'As this breed worked up into management and executive positions within the science-based corporations, they came to identify the advance of modern technology with the advance of these corporations.'[119] Around 1900 there was no contradiction in being an electrical engineer, a senior executive of an electrical concern and a convinced socialist. Charles Steinmetz, who combined all these positions — he was a manager at General Electric — believed that the large capitalist enterprise was 'the most efficient means of making individual development possible in our present state of civilization'.[120] (Lenin's famous formula: 'Electricity + Soviet power = Communism' is a radical echo of this social philosophy founded on electricity.)

What does all this have to do with the lamp?

Let us go back to the question of why psychological resistance to a central energy supply, so widespread in the nineteenth century, faded with the advent of the electric light bulb. We can now say that in addition to electricity's cleanliness, odourlessness and harmlessness, there was another factor that made it easier for people to accept a central energy source.

The nineteenth-century definition of a lamp *before* electrification was as individualistic as the mentality of enterprise capitalism. The new definition was as 'collective' as Steinmetz's opinion that the large enterprise guaranteed individual development. 'However perfect a lamp may be', wrote Parville in 1883, 'taken by itself it is not a complete lighting system. It is only one part of the whole system. One does not fill a lamp with electric current like oil.'[121]

An Imaginary Conversation

A few days ago, in one of the theatres with electric lighting, we chanced to overhear a conversation between an elegant lady and two well-spoken gentlemen in the row behind us.

119. David F. Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York, 1977), p. 19.
120. *General Electric Review*, vol. 18 (1915), p. 810, quoted from ibid., p. 42.
121. de Parville, *L'Electricité*, p. 375.

Title page of the journal *La Lumière électrique*, 1886

'Look', said the lady, 'the gas flames are upside down.'
'You are mistaken, my dear', replied her husband, 'they are electric lamps!'
'Yes indeed', explained the third, 'they are Edison lamps.'
'That's nice', said the lady, 'but if one of those lamps were to break, would it still give out light?'
'I don't think so', replied her husband, 'because then it would no longer have any electricity.'

'Ah, then the electricity is in the chandelier?'

'Of course.'

'No', said the second gentleman, 'the electricity is in the cellar or behind the sets, and it gets into the lamps via the wiring.'

'But tell me', exclaimed the lady, 'if one were to break a wire, would the electricity leak out into the auditorium? Wouldn't that be dangerous for the audience?'

'My dear wife', said her husband, bringing the conversation to an end as the performance began, 'one can breathe electricity without the least danger. And in any case, it would rise and collect under the ceiling at once, so we would have nothing to fear.'[122]

122. 'L'Electricité', *Revue scientifique illustrée*, 1 January 1887.

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