XIII: Soleil, Duboscq, and Their Successors

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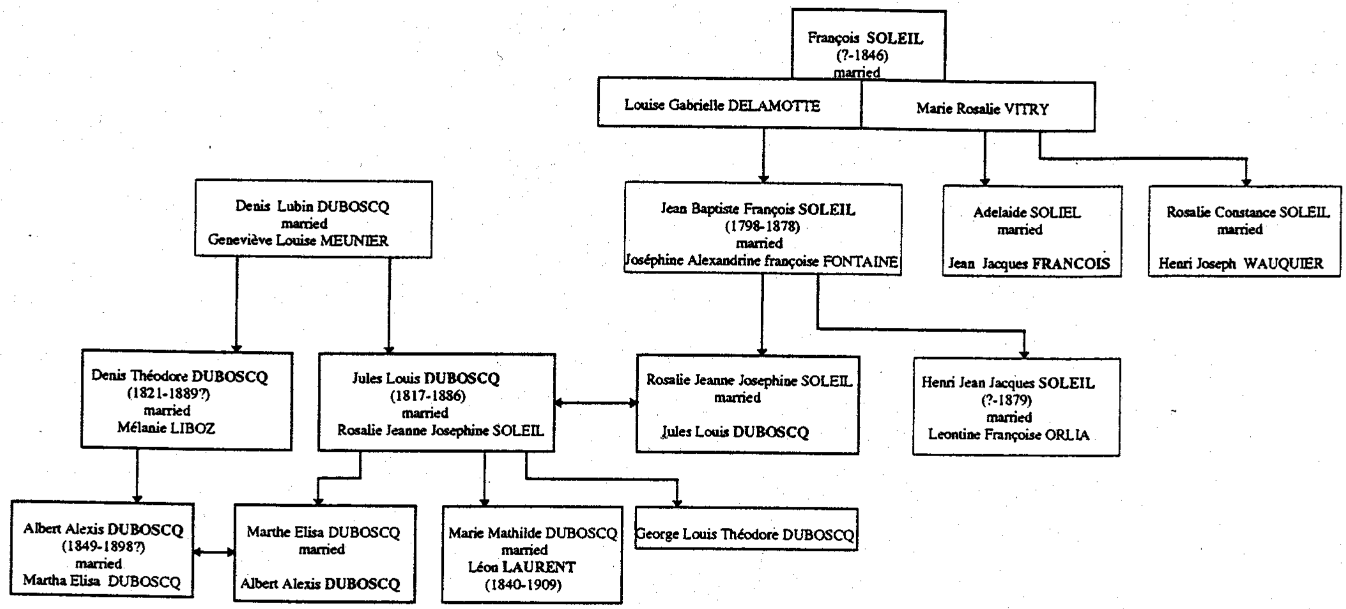
Simplified genealogical tree of the families Soleil and Duboscq
(The names of instruments makers or lighthouse manufacturers are in bold capitals)



The name Soleil can be considered emblematic for an optical instrument maker. In fact, among the most important French scientific instrument makers, the firm, founded by the Soleil family almost two centuries ago, was certainly one of the most prestigious, whose reputation was universally appreciated and whose products were exported worldwide.[1] The firm manufactured instruments for physical optics, sometime called *haute optique* or *optique supérieur*. This denomination included all the apparatus for studying, demonstrating, and measuring the most various optical phenomena, but it did not include microscopes and telescopes, which, apart from special exceptions, were rarely made by Soleil and his successors. The excellent quality and the extraordinary variety of their instruments was such that, for a few decades, the firm almost held a monopoly in this field of precision instruments.

Because of the complex family relationship among the members of this dynasty of scientific instrument makers it is necessary to show here a simplified genealogical tree (See Table above). Moreover, the members of the Soleil family had the annoying habit of signing their documents as well as their products without mentioning their first name. For these reasons, many bibliographical works and encyclopaedias confuse the biography of Soleil *grand-père* with the one of his son, often amalgamating them together.[2]

François Soleil (Soleil *grand-père*, ?-1846)

Very little is known about François Soleil, apart from the fact that his reputation was mostly due to his pioneering work in the field of lighthouse échelon lenses (Fig. 1).[3] In 1799, we find the optician François Soleil (Fig. 2) installed at 14, rue du Cimetière André (since 1844, rue Suger). One year later, his address was rue des Filles Thomas (which became a couple of years later 1, rue des Filles

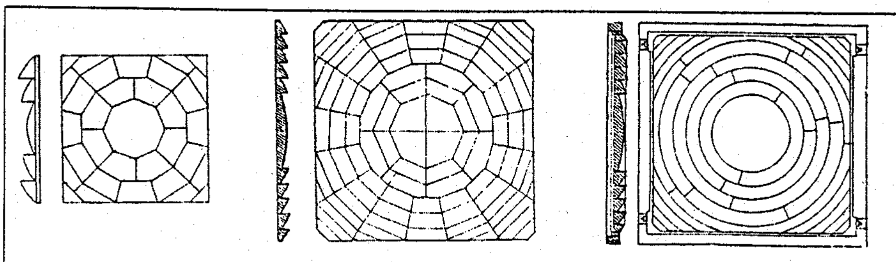


Fig. 48. — Lentille d'essai, 1820. Échelle de $\frac{1}{15}$.

Fig. 49. — Première lentille polygonale a échelons, de 1^er ordre. 1821. Échelle de $\frac{1}{15}$.

Fig. 50. — Première lentille annulaire a échelons, de 1^er ordre. 1821. Échelle de $\frac{1}{15}$.

Fig.1 *The first three Fresnel lenses made by F.Soleil. (From: E. Allard,* op.cit., *note 3).*

Fig.2 *Jean Baptiste François Soleil. (From:* Musée retrospectif de la classe 15 à l'exposition universelle internationale de 1900, *Paris, 1900).*

St.Thomas). In 1812, the address was rue des Filles St.Thomas 1, and 21, passage Feydeau, while after 1827, it was 23, galerie Vivienne.[4] During the first decade of the century, Soleil was advertising the construction of a telescopic rangefinder. It was probabely the *lunette micrometrique* with a birifrangent prism which had been proposed by the French scientist and explorer Alexis Marie du Rochon (1741-1817). In 1812, F.Soleil got a royal patent for the invention of the *propiographe,* which was a kind of improved camera obscura.[5] A few years later, he also advertised microscopes, achromatic telescopes and various optical devices. In 1819, Soleil married Josphine Alexandrine Françoise Fontaine (1800-1875) and started a profitable collaboration with one of the most famous physicists of his time: Augustin Jean Fresnel (1788-1827). In spite of a very short life, Fresnel's contributions to the study of the nature of light remains a cornerstone in the history of physics which can hardly be summarised in a few words. He was able to demonstrate mathematically that the diffraction phenomena could be explained by considering light as a wave. Furthermore, Fresnel explained the double refraction and polarization phenomena by assuming that light waves were transversal. (The corpuscular theory as well as the longitudinal wave theory were inadequate to explain double refraction). In June 1819, Fresnel was appointed to the French Lighthouse Commission. The Commission, which had to improve the performance of lighthouses, was established in 1811. At the time, the largest lanterns were equipped with Argand lamps[6] with metallic parabolic reflectors, which were expensive as well as difficult to manufacture and to maintain. Moreover, the loss of light by reflection was more important than by lens refraction. However, large lenses would have been very difficult to manufacture, and would have been too thick and very heavy. A couple of months later, Fresnel proposed his first échelon lens to consist of several prismatic rings of glass.[7] The Commission agreed to finance the prototype and Fresnel asked the maker F.Soleil to undertake the delicate work. The reasons for Fresnel's choice are unknown. At first it was impossible to produce the anular prisms required by Fresnel because of technical difficulties and lack of proper working tools. Thus, it was decided to divide the rings up into different pieces of glass with a spherical curvature, which could be manufactured with the usual lens-making tools. The pieces had then to be glued together. Furthermore, because of the poor quality of the glass blanks provided by the manufacture of Choisy le Roi, Soleil was obliged to reheat and to compress them in order to obtain some suitable pieces of glass.[8] In 1820, Soleil first made a polyzonal lens of 35 cm diameter, and at the beginning of 1821 he completed a second one of 55 cm and with a focal length of 70 cm. A a few months later, a lens of 76 cm diameter was completed. The glass sectors, which composed the first lenses were flat on one side and curved on the other. The experiment and the test with these prototypes were highly satisfactory and convinced the Commission, which ordered a series of eight of them (76 cm) to be installed in the Cordouan lighthouse, one of the most important in France. Meanwhile, Fresnel asked the director of the Saint-Gobain glass factory to try to produce the pieces of the prismatic rings (which approximately should have the desired shape) by directly moulding their sections in cast iron moulds. The results were quite good and Soleil could work these sections of arc avoiding the previously necessary long and difficult operation of reheating and compressing them (*refoulement*). Furthemore, Soleil, following Fresnel's suggestion and thanks to financial help from the governement, provided the machinery, which was necessary for grinding and polishing the prismatic rings. The rings (actually their sections) were glued to the horizontal rotating disk of a vertical lathe, while two special moveable arms bearing the working tools shaped their faces.[9] Around 1821, Soleil bought a house at the Chapelle St. Denis, in the outskirts of Paris, where he subsequently installed a larger workshop. Here, the lathes and the various machines were horse-powered. The lantern for Cordouan was tested in July 1822 on the *Arc de Triomphe* at the *Place de l'Etoile* and the experiment attracted the curiosity of the Parisians. The lantern was completely ready one year later and it was installed in the lighthouse. The success of the new system was clear and aroused interest also outside France.[10] In 1825 the Commision decided to adopt Fresnel's system for a series of 27 large lighthouse lanterns and a comparable number of smaller ones. Meanwhile, Fresnel was conceiving a new system for collecting and deviating the light coming from the upper and under part of the lantern by means of total reflection achieved by anular prisms. In Fresnel's first lantern, this portion of almost vertical rays was reflected horizontally by flat metallic mirrors.

So, in the 1820s and early 1830s Soleil was completely absorbed by his work with the lenses. Thus when the orders for new lighthouses arrived, Fresnel also tried to involve first the maker Henri Prudence Gambey (1787-1847) and then the Jackers brothers in the production of echelon lenses. Gambey did not show any enthusiasm for the project, and the results of the Jackers's work was disappointing. As it turned out, for several years Soleil remained the only manufacturer of this very special apparatus. At the French national exhibitions of 1819, 1823, 1827 and 1834, Soleil was awarded silver medals for his lenses. In 1838, Soleil *grand père* rented his workshop for the construction of lenses and lighthouse lanterns to his son-in-law Jean Jacques François.[11] The activity was successfully continued. François subsequently passed the business on to his son-in-law Létourneau. In 1852, the firm was bought by L.Sautter, who in 1870, in association with Lemonnier, created the *L.Sautter, Lemonnier & Cie,* which for many decades was one of the most important French manufacturers in this field.[12] In the same year, François Soleil was hit by cerebral paralysis. Completely unable to carry on any kind of activity, he survived until 1846.

Jean Baptiste François Soleil (Soleil *père,* 1798-1878)

The important activity in the production of sopisticated laboratory instruments really began with Jean Baptiste François Soleil (1798-1878), the son of François.[13] After the obscure early years, during which he had a rudimentary education, Soleil followed the physics courses of the famous scientist Jacques Alexandre Charles (1746-1823). It seems that he was also an apprentice in the Parisian workshops of the instrument maker Haering (appointed by the Duke of Orléans and by the king of Würtemberg) and of the mechanician Palmer, who were both active during the first decades of 19th century.[14] In 1823, Soleil *père* appeared for the first time in the records as optician at the 7, rue de Nazareth and two years later, he was established at the 35, rue de l'Odéon. The firm remained at this location until the beginning of the 20th century, even if around 1851 the address number changed from 35 to 21, due to a change in the numbering of Paris streets.

At the beginning of his career, J.B.F.Soleil followed the activity of his father. In fact, from the correspondence of Fresnel, we know that he also spent some time constructing and improving the mechanical parts of lighthouse lanterns. In 1834, he was for the first time present at a national exhibition, where he exhibited independently from his father. It was most likely Fresnel and his brother Léonor who introduced J.B.Soleil to the physicist Charles Babinet (1794-1872) and to some other leading French scientists of the time, who stimulated the scientific interest of Soleil. He became fascinated by the recently discovered optical phe-

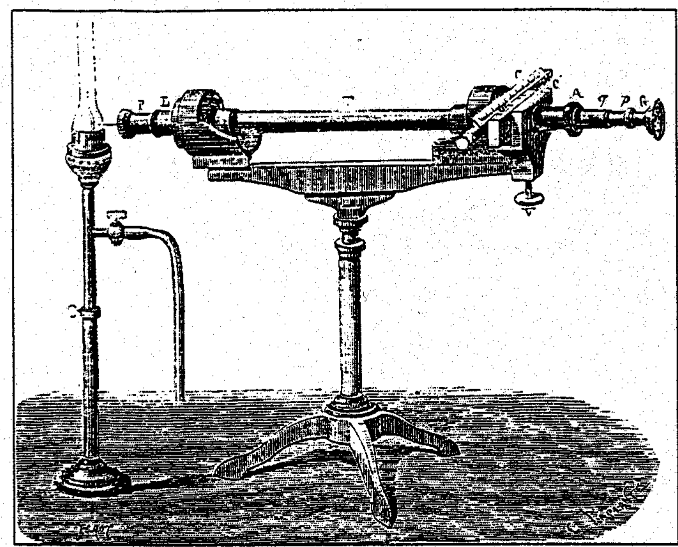


Fig.3 *J.B. Soleil's saccharimeter. (From: H. Buignet,* Manipulation de physique, *Paris, 1876, p. 522).*

nomena, and dedicated all of his time and energy to inventing, improving and manufacturing optical apparatus. In the first half of 19th century, thanks to the research of T.Young, D. Brewster, A.J. Fresnel, E.T. Malus, J.B. Biot, J.F. Arago, C. Babinet and others, such optical phenomena as diffraction, interference and polarization were systematically studied. In fact, almost all French scientists and several European ones, who were involved in optical research, required the skill and the ingenuity of Soleil for turning their ideas into instruments. Soleil established the definitive design of many pieces of apparatus, which then became 'classical' demonstration and research instruments for almost a century. However, it would be completely wrong to think that he was the mere executor of other people's projects. Soleil's original contribution to instrumental optics was fundamental. The list of apparatus presented by him at the *Académie des Science* is impressive.[15] In 1838, he proposed a device for projecting the phenomena of chromatic polarization; in 1839, a Babinet goniometer, a polarizing microscope for determining the angle of bi-axial crystals and a complete optical bench with accessories for reproducing several experiments concerning diffraction and interference. In 1841, he presented a polarimeter following the instruction of F.Arago, an improved pocket-microscope and an échelon burning lens. In the same year, he also proposed a curious coffee percolator![16] In 1842, he built for the physicist Theobald Silbermann (1806-1865) an heliostat, which was simpler and cheaper than the Gambey's apparatus, commonly used at the time. Soleil's version was much appreciated and was used until the 20th century. He also made the polarizing microscope according to the ideas of the Italian scientist Giovan Battista Amici (1786-1863). In 1844, he wrote an article in the *Compes Rendus* describing an instrument for studying Newton's rings[17], and he presented, again with T. Silbermann, an ingenious apparatus for demonstrating the laws of reflection and refraction. A year later, he made some observations on optical properties of quartz[18] and he proposed the use of double quartz plates for measuring small angles of rotation of a polarized beam of light[19], as well as a double quartz wedge 'compensator' for polarimetric measurements.[20] In the 1840s, Soleil, who made several polarizing instruments according to Biot's suggestions, was perfecting his own saccharimeter. This was a very important instrument, because by making use of the optical activity of sugar solution, it could make fast and precise determination of their concentration without the need for lengthy chemical analyses. Around 1845 Soleil presented his white-light saccharimeter, and in 1847, he invented a 'colour generator' for improving the performance of this instrument[21], which was finally described in a report at the *Académie* in 1848. This sacharimeter (Fig. 3) was much better than other similar instruments and Soleil was awarded a gold medal by the *Société d'Encouragement de l'Industrie nationale,*[22] which had instituted a special prize for a precise and simple method for determining the concentration of sugar in solution. This instrument was soon adopted in the sugar industry. Many other sophisticated instruments, such as the polarimeter and the cyanopolarimeter of Arago (the latter was an instrument for determining the blue colour of the sky compared to a blue produced by chromatic polarization), as well as the 'polar-clock' invented by Charles Wheatstone (1802-1875) in 1848, were made and improved by Soleil.[23] With the polar-clock, it was possible to determine the solar time from the polarization of light in the sky, which depends on the position of the sun.

Like many other opticians, Soleil also became interested in photography and immediately after the official presentation of the invention of Louis Jacques Daguerre (1787-1851) in 1839, he was able to produce his own daguerrotypes and to suggest some improvements in photographic technology.[24] He also published one of the first French booklets on this topic.[25]

Soleil participated in the French national exhibition of 1834 (*mention honorable*), 1839 (bronze medal) and 1844 (silver medal). In the 1840s, his reputation was well established because of his superb instruments, and also because of his close relationship with many of the scientists of the time, who often profited from his skills, as well as from Soleil's own apparatus. His optical instruments were equipping the most prestigious Parisian laboratories (we can only mention the one of the *Collège de France)* as well as the cabinets of many foreign institutions, both in Europe and in the United States. The 1849 French national exhibition crowned Soleil's career. He was awarded a gold medal and in the same year, he became *Chevalier de la Légion d'Honneur.* At the very beginning of 1850, Soleil *père* retired. He sold his business to his son Henri and his son-in-law Jules Duboscq.[26] Henri Soleil got the workshop for the production of optical glasses and crystal as well as the retail shop, while Duboscq acquired the workshop for the construction of scientific instruments. The contract stated that Henri Soleil had to pay his father an annuity of 500 francs while Duboscq one of 450 francs.[27] Both workshops were located at the same address (35, rue de l'Odéon), but it was clearly stated that they were completely independent. The two branches, born from the original firm were, in fact, to develop separately.

Henri Soleil (Soleil *fils*, ?-1879)

Very little is known about Henri Jean Jacques Soleil (?-1879), son of Jean Baptiste Soleil and Josephine Fontaine.[28] His work followed the family tradition, but his reputation never reached that of his father's. His workshop, which he acquired from Soleil *père* in 1850, was dedicated to the production and working of optical glasses, lenses, prisms and special crystal plates which were necessary in many experiments as well as for optical instruments. In his adjacent shop, he also sold simple microscopes, spectacles, binoculars and other common instruments, such as barometers, thermometers and hydrometers, which probably were also produced by other makers. Nevertheless, in the 1850s and 60s H.Soleil published several articles in the *Comptes Rendus de l'Académie des Sciences* on crystal optics, a double refracting prism rangefinder, the standardisation of spectacle lenses and various other instruments.[29] In 1866 Soleil won a 1000 francs prize (*prix Bordin*) from the *Académie* for a memoir concerning the art of cutting quartz plates following a precise orientation.[30] Finally, in his last note for the *Comptes Rendus*, he suggested the possibility of using beryllium for making standards of length.[31] Henri Soleil presented his optical elements at the Paris universal exhibitions of 1855 (second class medal) and of 1867 (silver medal). Soleil had acquired a great skill in the difficult task of shaping and polishing glass and mineral plates for the needs of optics. In a catalogue he published in 1867 he listed about 200 items. Apart from a few optical instruments, they were mostly cut crystals, lenses, prisms and other special glasses. It appears that by the beginning of the 1870s the activities of the firm were quite reduced because, when Léon Laurent bought it in 1872, the workshop employed only one optician. H.Soleil finally retired in the same year and died in 1879.

Léon Laurent (1840-1909)

Léon Laurent was born in Soisson (Aisne) in 1840.[32] He attended the school *Turgot* in Paris from 1853 to 1856 and, in the same year he entered as a draftsman in the firm of Gustave Froment (1815-1865), the very famous instrument maker. In 1865 he was awarded a bronze medal from *Société d'Encouragement* for having been one of the best workers and collaborators of Froment. For the same reason, he won a second medal at the Paris exhibition of 1867. In 1870, after 14 years with Froment, Laurent married Marie Mathilde Duboscq, daughter of Jules Duboscq, and entered this firm at the rue de l'Odéon. Two years later, thanks to a family agreement, Laurent succedeed to Henri Soleil. He was able to revitalize the languishing workshop and in 1877, he had about 20 employees in his workshop plus a few other ones working at home. In 1873, Laurent successfully participated to the Vienna universal exhibition.

Saccharimeter (a family business!) played an important rôle in the second half of the 19th century food industry and similar instruments, often called diabetometer, were used in medecine for measuring the amount of sugar in urine.[33] For these reasons, quite a large number of

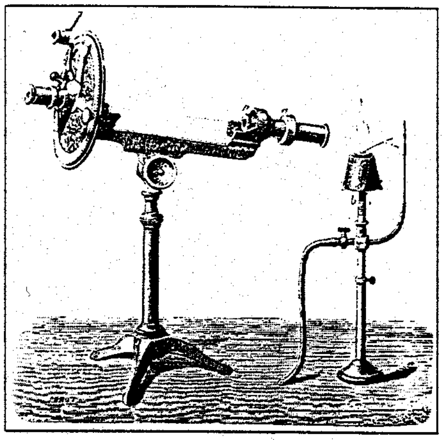


Fig.4 *Laurent's half-shadow saccharimeter with sodium monochromatic lamp (From: H. Buignet,* Manipulation de physique *(Paris, 1876), p. 530).*

polarimetric apparatus were required, and, therefore, they were economically interesting for optical instrument makers. In 1874, Laurent proposed the half-shadow saccharimeter (Fig. 4), which represented an improvement compared to the Soleil's instrument.[34] In these instruments, monochromatic polarized sodium light illuminated the optical active solution, and in its eyepiece, appeared two differently illuminated yellow areas. By carefully rotating the analyzing prism, the illumination of the two areas could be equalized. This operation was easier than to match the right nuances of colour with Soleil's white-light saccharimeter. Laurent's apparatus was succesful and, between 1875 and 1886, he sold about 1250 of them. Many were bought by the government's department of customs and taxes as after 1875 in France, the duty which had to be paid on sugar was based on the saccharimetric degree of its solutions. In 1876, Laurent was awarded a platinum medal for his saccharimeter by the *Société d'Encouragement*. His 1878 catalogue has a list of more than 400 items. That year he participated in the Paris universal exhibition and again was awarded two gold medals for his apparatus. In the same year, he became *Chevalier de la Légion d'Honneur*. Laurent not only developed and produced new research and demonstration instruments such as projectors, lamps, colorimeters, polarizing microscopes, spectroscopes, etc.,[35] but for about 20 years he also constantly worked on improving their optical elements, by developing parallel glass plates, lenses and prisms. At this time these elements were produced by trial-and-error procedures, and there was almost no simple and efficient apparatus for testing them.

In trying to introduce fast and reliable procedures for improving the manufac-

Fig.5 *Jules Duboscq. (From:* Musée retrospectif de la classe 15 l'exposition universelle internationale de 1900, *Paris, 1900).*

ture of glass parts, Laurent invented a series of special instruments for testing and measuring the optical characteristics of lenses, prisms, and parallel plates of glass and crystals.[36] These instruments made possible the production of optical elements of better quality. Laurent stated that, at the time, he was the only one in France to systematically use such apparatus in the workshop. At the same time he proposed new methods for manufacturing eyepieces and polarizing prisms.[37] Finally at the 1889 Paris universal exhibition, he was awarded a *grand prix*. In 1892 Laurent retired and sold the firm to Amedée Jobin. Léon Laurent died in 1909.

Amédé Jobin (?-1945)

Very little is known about the life of Amédé Jobin. He had an academic education, and studied at the prestigious *École polytechnique*. He then attended the military school of Fontainbleau, and became a lieutenant in the artillery. In 1885, he retired from the Army and began his career in the instrument-making industry by buying Laurents's firm. Like Laurent, Jobin tried very hard to modernize his firm and introduced the best machines and techniques for manufacturing optical apparatus. His instruments, which were often developed in collaboration with highly distinguished scientists such as Charles Fabry (1867-1945), were at the beginning of the century of a strikingly modern design. Particularly important were Jobin's interferometric apparatus. Between the end of 19th century and the first decades of 20th century, Jobin's optical instruments were among the most sophisticated produced in Europe and his firm was among the most important ones such as Zeiss in Germany and Adam Hilger in Britain. In 1911, the address of Jobin's firm was 31, rue Humbolt. In 1921, Jobin was elected *artiste* of the *Bureau des Longitudes*, where he succeeded the maker Jules Carpentier (1851-1921).[38] In the 30s, when the firm was in Arcueil (26, rue Berthollet) near Paris, he became associated with the engineer Gustave Yvon. Jobin died in 1945, but his name survives in the firm *Jobin Yvon*, located in Longjumeau near Paris, which as part of the international company *Instruments S.A.* still produces high-precision optical apparatus today.

Jules Duboscq (1817-1886)

Few scientific instrument makers can perfectly represent the golden era of the French precision industry as well as Jules Duboscq (Fig. 5). Louis Jules Duboscq was born in 1817 in the village of Villennes (Seine-et Oise). His father was a cobbler. We do not have any information about Louis's earlier years, but in 1834, at the age of 17, he entered the workshop of Jean Baptiste François Soleil (Soleil *père*), where he started his apprenticeship. In 1839, Duboscq married Rosalie Jeanne, one of J.B.Soleil's daughter. As I mentioned above, in 1849, when Soleil retired, Duboscq got from his father-in-law the workshop for the construction of scientific instruments. Duboscq's activity as owner of the firm lasted almost 40 years, which coincided with the most successful period of French instrument making. Following his father-in-law's tradition (for a short time around 1850 he was even known as 'Duboscq-Soleil')[39], he became one of the most famous instrument makers in the world. The reputation of his instruments for physical optics was unsurpassed, a fact reinforced by the large number of his apparatus still extant in European and American museums and collections.

The 1851 London Great Exhibition was an excellent international shop window for Duboscq's apparatus. He had a large display of devices (saccharimeter, heliostat, cyanopolarimeter (Fig. 6), arc-light apparatus, goniometer, and various other apparatus for the polarization phenomena) which aroused the admiration of British as well as foreign visitors. Duboscq's physical optics instruments were considered the best of the exhibition and he was awarded a Council Medal. But the exhibition also represented for Duboscq a great opportunity for popularizing Brewster's stereoscope. The Scottish scientist David Brewster (1781-1868), had proposed his lenticular stereoscope

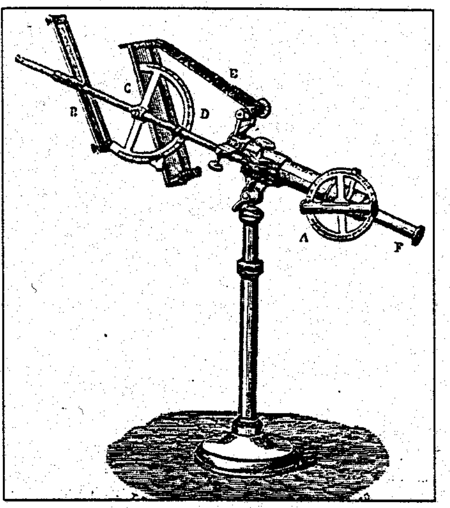


Fig.6 *Arago's cyanopolaimeter made and improved by Duboscq. (From: J. Duboscq,* Historique et catalogue...,op.cit., *note 53, p. 28).*

around 1846, but he had not found any British optician really intrested in it. In 1850, Brewster while in Paris visited the workshop of Duboscq, who immediately showed his curiosity for the stereoscope. He began to manufacture the apparatus as well as to produce stereoscopic pictures. In 1851, he displayed them in London where the stereoscope attracted the attention of Queen Victoria during one of her visits to Crystal Palace. As a consequence Duboscq manufactured a beautifully made stereoscope, which he offered to the sovereign before the closing of the exhibition. Immediately, several British and continental makers started to produce stereoscopic apparatus and images, and it seems that within a few years hundreds of thousands of stereoscopes were sold. In any case, this apparatus probably became the most succesful popular optical toy ever made. In spite of the apologetic claims of the journalist and physicist Abbé François Napoléon Moigno (1804-1884), who was a closed friend of many French scientists and makers, Duboscq was not the first one to produce stereoscopic photographs. Nevertheless, he was largely responsible for their improvement and popularisation. In fact, his stereoscopic daguerrotypes were among the best ever made. He developed several different models, such as the panoramic stereoscope and the pseudoscope, and, with the English inventor Knight, he introduced larger and more luminous lenses.[40] For his work in the field of stereoscopy Duboscq was awarded in 1857 a gold medal by the *Société d'Encouragement de l'Industrie nationale.*[41]

Duboscq, like his father-in-law, was always interested in photographic technology, and he was himself a skilful photographer, who today is considered a real master of early photographic still life.[42] In 1855, together with the chemist Henri Edme Robiquet (1822-1860), he improved the method of preserving dry collodion plates,[43] and in 1861, he proposed a *polyconograph*, a camera attachment with a series of moveable plateholders, which made it possible to produce a large number of small pictures on a single plate. In the 1860s the famous microphotographs of René Dagron (1819-1900) were produced with Duboscq's equipment, and in the same years Duboscq presented an arc-light apparatus for enlarging photographic images. During the Paris siege of 1870, Dagron was able to produce gelatine microphotographs (6 cm²) of printed messages containing up to 3 or 4 thousand dispatches, which were mailed from and to Paris by pigeons. The messages were subsquently magnified with the projection lantern and arc lamp of Duboscq, who also produced stereomicrophotographs.

Duboscq also made several pioneering experiments on moving image technology.[44] Around 1855, he proposed a very interesting apparatus, the projection phenakistiscope. Two parallel disks were rotating at different speeds in front of a projection lantern. A series of images in sequence (between 10 and 16) were painted on the glass disk, which was near the light source, while in the second one (made of wood) was embedded a series of lenses. The latter disk worked, in fact, at the same time as a condenser as well as a shutter. The projection phenakistiscope never became very popular, but it was advertised in the firm's catalogues almost until the end of the century. Again in the early 1850s, Duboscq invented an apparatus that combined the moving images effect of the phenakistiscope with the tridimensional effect of the stereoscope. The instrument, which was called *stéréofantascope* or *bioscope*[45], was, in fact, a phenakistiscope with a series of superimposed (and not adjacent) stereoscopic images. The observer had to look in a couple of small mirrors through the radial splits of the rotating disk of the phenakistoscope. The mirrors were so orientated that one reflected the upper image to the right eye, while, with the left eye, it was possible to see the lower image of the stereoscopic pair. Unfortunately, it seems that today no *stéréofantascope* has survived in spite of the fact that it could be found in Duboscq's catalogues until 1885.

It would be impossible in the limited space of this article to present all the optical instruments manufactured and often invented or improved by Duboscq. Almost all the leading French scientists,

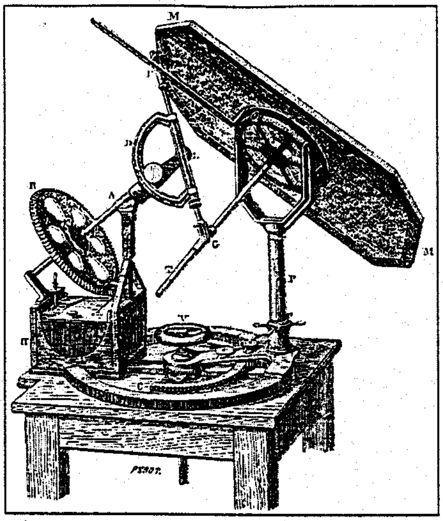


Fig.7 Large *Foucault heliostat made by Duboscq in 1863. (From: J. Duboscq,* Historique et catalogue...,op.cit., *note 53, p. 4).*

(such as L.Pasteur, J.Jamin, C.Babinet, L.Bertin, A.Crova, J.Violle, Ed. Becquerel), and several foreign ones, required the assistance and the skill of this maker for the realization of their instruments. Many optical instruments in the physical cabinets from Edinburgh to Naples and from Harvard to Vienna were manufactured in Duboscq's workshop in rue de l'Odéon. A few of them were described by Duboscq himself in several articles while many others were described by distinguished physicists.[46] And, in fact, from the correspondence between Duboscq and many scientists[47] it is possible to see the closeness of this collaboration and the continous transfer of technological and scientific know-how that was taking place between them and the maker. In 1849, he proposed the automatic arc-lamp regulator with fixed arc, which represented a substantial improvement

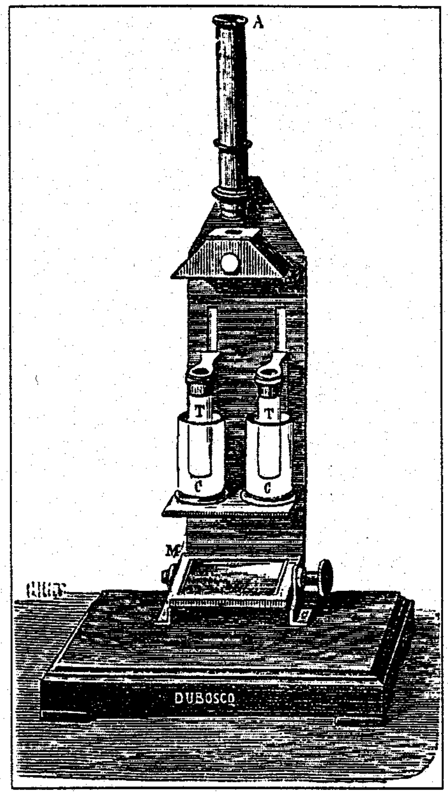


Fig.8 *Duboscq's colorimeter. (From: J.Duboscq,* Historique et catalogue...,op.cit., *note 53, p. 92).*

over the one invented by Léon Foucault (1819-1868).[48] Because of his lamp, Duboscq won in 1856 a gold medal from the *Société d'Encouragement*. In the 1850s and in the early 1860s he continued to improve electric arc-lamps (together with Foucault) as well as a projection lantern with several different accessories, which became a must in the physical cabinet of the second half of the century. Duboscq also introduced and popularized the use of positive tranparencies. In 1862, he proposed a very large heliostat (Fig. 7)[49], and, in 1868, he invented a colorimeter (Fig. 8), which with a few modifications was used for more than a century. This instrument allowed for the comparison of two coloured solutions of the same substance of different concentrations and whose colour density could be easily varied. Knowing the concentration of a standard solution, it was possible to determine the concentration of the second one.[50] Lenses, prisms, optical benches, light sources, and optical demonstration and projection apparatus of every kind (Figs 9 and 10),[51] spectroscopes and spectrometers (Fig. 11), photometers, colorimeters, refractometers, goniometers, interferometers, polariscopes, polarimeters and saccharimeters[52], phosphoroscopes, optical toys were all illustrated and described in Duboscq's catalogues.[53]

Duboscq's activity was manifold. Not only did he own and direct the firm, supervise the production, as well as invent new instruments and improve old ones, he was also a very skilful experimenter and an incomparable demonstrator. In the latter field, Duboscq was an indispensable companion of the scientists who were presenting scientific public lecture-demonstrations during the Second Empire. The omnipresent Abbé Moigno, editor of *Cosmos*, carefully reported these events, which were held at the *Conservatoire des Arts et Métiers*, at the *College de France*, at the *Sorbonne* and also at the court in front of Napoléon III and the imperial family. These events were very successful not only because of the name of the illustrious speakers, who were often the most important French scientists, but also because of the beautiful experiments that were performed. Duboscq, as well as other makers such as Heinrich Ruhmkorff (1803-1877), were always ready to lend their instruments

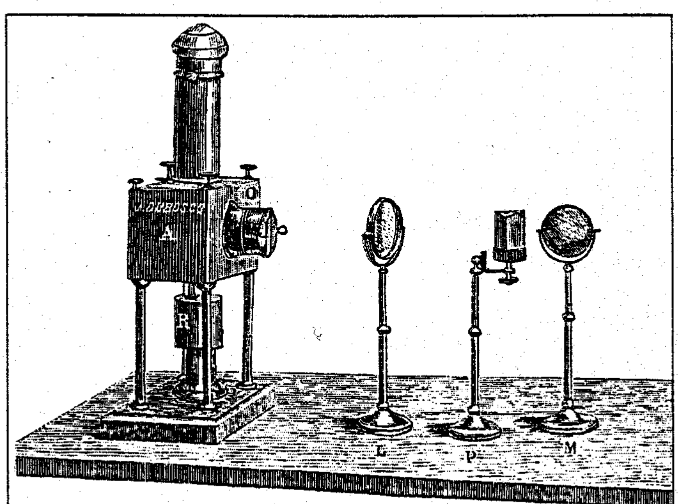


Fig.9 *Duboscq's lantern and arc-lamp with prism and lenses (From: J. Duboscq,* Historique et catalogue...,op.cit., *note 53, p. 62).*

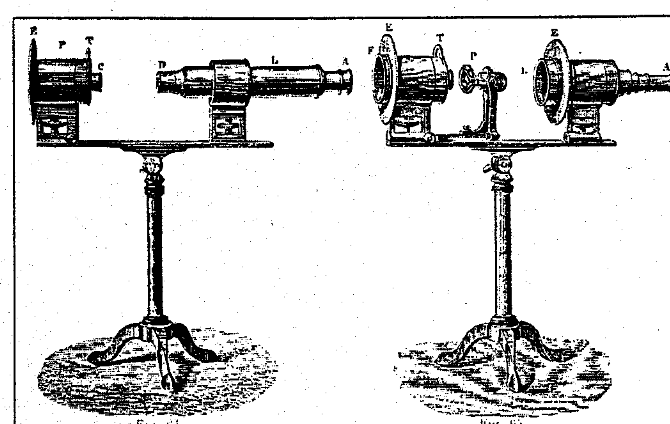


Fig.10 *Duboscq's apparatus for projecting various phenomena of polarization. (From: J. Duboscq,* Historique et catalogue...,op.cit. *note 53, p. 84).*

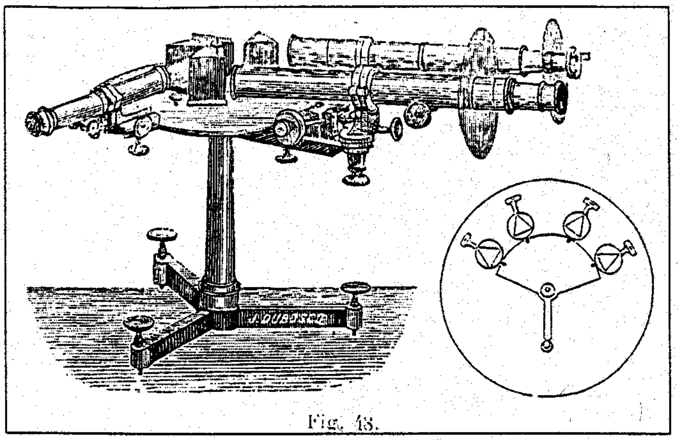


Fig.11 *Four-prism spectrometer made* by *Duboscq. (From: J. Duboscq,* Historique et catalogue...,op.cit., *note 53, p. 53).*

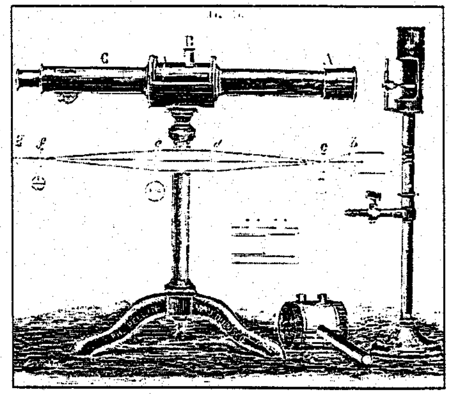


Fig.12 *Piltschikoff's refractometer made by Pellin. (From: N. Piltschikoff, Réfractométre lentille pour liquide,* Journal de physique théorique et applique, *II série, 8, 1889, p. 413).*

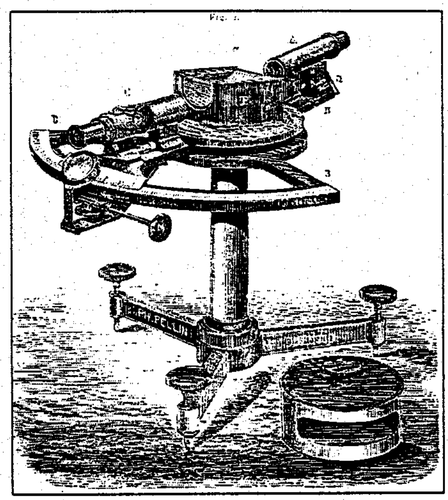


Fig.13 *Dupré's refractometer made by Pellin (From: Ph. Pellin, 'Refractomtre de M. Dupré',* op.cit., *note 63, p. 413).*

and to show in front of a fascinated audience, the chromatic phenomena of polarization and interference, the projection of Lissajous's figures or the images of a photoelectric microscope.[54]

Because of his practice with arc-light technology, Duboscq was, for several years, responsible for the first electric lighting system of the Paris Opéra, where electricity was provided by a series of 480 large Bunsen cells![55] At the same time, he invented a series of curious devices, which were sometimes modified laboratory instruments, for producing new and impressive special effects on the stage. For example, he proposed an optical apparatus for projecting a rainbow in the theater. Until then this meteorological phenomenon was simply produced by illuminating a rainbow painted on a canvas. Furthermore, he made a special arc lamp, which proved to be very good for simulating the flash of lightening, proposed a lantern for projecting the effect of sunrise, and he invented several devices for producing luminous fountains and other spectacular tricks.[56]

In the early 1870s, Duboscq, while keeping the old address at 35, rue de l'Odéon for the shop, transferred the workshop a few hundreds yards away to 30, rue Monsieur le Prince. In 1878, Duboscq filled in a form for participating at the third Paris universal exhibition. From it we have some information about the organization of his firm. Duboscq then employed 36 men and 3 boys. Another 20 men were Duboscq's subcontractors, employed outside his workshop. The value of the instruments sold in France was around 60,000 francs a year, while another 120,000 francs of instruments were exported annually. The workshop seemed to be well equipped with machine tools such as lathes, drills, planing and milling machines, which were driven by a 1HP gas engine. At the time, a visit to Duboscq's company was a must for every scientist travelling to Paris.

Duboscq's apparatus were constantly and successfully presented at the international and universal exhibitons. In fact, only a very few scientific instrument firms so systematically participated in all the important European and American universal exhibitions.[57]

A few relatives of Jules Duboscq were also involved in instrument making. His brother Théodore (1821-1889?) was for a long time technical director of the firm. He was awarded a 'cooperation prize' at the 1878 Paris exhibition for 15 years of collaboration. In 1879, Jules Duboscq formed a partnership with his nephew and son-in-law, Albert Alexis Duboscq (1849-1898?)[58] who, in 1873 had married Jules's daughter, Marthe Elisa Joséphine.[59] But, for an unknown reason, this firm did not last very long as it was dissolved in 1882. In the 1880s Théodore Duboscq and his son Albert Alexis were installed as instrument makers at 11, rue des Fossée-Saint Jacques. They participated in the Amsterdam international exhibition of 1883 and in the 1885 Antwerp exhibition. Albert Alexis was also present in Barcelona in 1885 and in Paris four years later. However, it does not appear that this 'parallel' firm was very successfull and it had quite a short life. Nevertheless, Albert and Théodore also proposed a few original projection and demonstration apparatuses.[60]

In 1881 the *Société d'Encouragement* yet again honoured Jules Duboscq with a *rappel* of a gold medal for his instruments. In 1885, the 68-year-old maker associated with his collaborator Philibért François Pellin, in a new company called *J.Duboscq et Ph.Pellin,* whose trade mark was *Maison Jules Duboscq.*[61] Duboscq's supervision of the firm remained constant even if his activity was slowing down. In 1886, a few months before his death, Jules Duboscq became *Officier de la Légion d'Honneur.*

Duboscq's successors: Philibért François Pellin (1847-1923) and his son Félix Marie (1877-1940)[62]

Philibért Pellin, who was born in 1847, in Paris, represented a new generation in the firm. In fact, contrary of his predecessor, he had an academic background. He entered the *École des Arts et Manufactures,* where he became civil engineer in 1870. One year later, he joined Kriegelstein, who was a piano maker, and in 1883 he started his collaboration with Duboscq. In 1885, he formed a partnership with him, and finally he became the owner of the firm in 1886. Pellin continued Duboscq's tradition and his workshop produced some of the best French optical instruments, which he illustrated in several articles.[63] The world renowned firm systematically continued to be present at the national, international and universal exhibitions sometime *hors concours*, and from the end of the century, Philibért Pellin and later his son, Félix, played an increasingly important rôle as a *membre du comité d'installation* or *membre du jury* in organizing these events.[64] In 1890, Pellin was awarded a gold medal for his instruments (refractometers (Figs 12 and 13), spectroscopes, etc.) by the *Société d'Encouragement*.[65] Furthermore, he became a leading member of the council of the *Société française de Phyisique*, president of the *Syndicat patronal des constructeurs en instruments de précision*. *Chevalier de la légion d'Honneur* in 1894 and *Officier de l'Instruction publique* in 1894. At the end of the century, Pellin enlarged the field of production. Besides the optical instruments which represented almost a century of tradition of the firm, he began to manufacture meteorological, magnetic and wireless apparatus. Around 1900 Pellin was publishing eleven different catalogues which divided the firm's output into different specialities. The instruments were profusely illustrated. Very often, these booklets reproduced part of the articles describing these instruments which were published in scientific periodicals. Tables, graphs and drawing enriched the catalogues, which could be used as treatises on instrumental physics.

At the beginning of the 20th century Pellin also tried to expand the firm's activities, necessary if the firm was to remain important. The renown of Pellin in France and abroad was well established, but the growing competition of foreign firms such as the German Fuess, Zeiss, Franz Schmidt und Haensch, and the English Adam Hilger was reducing the opportunity for French instrument manufacturers to export. In fact the Duboscq era, which saw the supremacy of French scientific instruments, was over, but, nevertheless, Pellin father and son successfully continued their activities. In 1900, Félix Marie Pellin (1877-1940), who had studied at the *École polytechnique*, joined his father in the firm. A year later he became technical director, and finally the general director in 1903. Around 1909, after many decades at the rue de l'Odéon and rue Monsieur le Prince addresses, the shop, offices and workshop of the firm were moved to a new and larger location at 5, avenue d'Orléans. In 1912, Félix Pellin joined his father under the name *Philibért and Félix Pellin*. In the same year Philibért became *Officier de la Légion d'Honneur*. Because of World War I, the German scientific instrument industry, which at the beginning of the century had been extremely powerful and successful, was severly hit by the defeat and lost part of its international market. Pellin was keen to profit from this situation and to improve the performances of his firm. One of his collaborators was sent to the USA to study the new manufacturing techniques as well as the business organization on the other side of the Atlantic. At the same time Pellin tried to establish profitable deals with some of the most important American scientific apparatus firms (CENCO, Leeds and Northup, Weston).[66]

Félix Pellin's activity was largely absorbed by a series of official duties for the Minisery of Commerce (in Brazil in 1922, in Germany 1932, in Austria 1933), as member of several industrial commissions (*Chambre syndicale de l'optique*, *Société de physique*), and as a member of the boards of different institutes (*Institut d'optique*, *Office national des Recherches et Inventions*, *Conseil de Perfectionnement du CNAM*). He became *Chevalier de la Légion d'Honneur* in 1921. In fact in the first decades of the 20th century Philibért and Félix Pellin's efforts were concentrated on politics, management and public relations, while development and production of apparatus were now usually in the hands of technical directors and engineers. In 1927 Félix Pellin became the owner of the company who took his name. Finally around 1941, after the death of Félix Pellin, the firm merged with the *Société industrielle d'instruments de précision*, which in 1911 had become the successors of the firm of Deleuil.[67]

The history of the firm originally founded by Soleil *grand-père* is a magnificent example of the development of the French precision industry between the beginning of the 19th century and the first decades of the 20th. Soleil *grand-père* and Soleil père represent the period of rapid developement of scientific instrument manufacture, when the French makers began to be internationally known and appreciated. During Duboscq's and Laurent's years, the reputation of the instruments produced in Paris, which especially in the field of physics and physical optics reached its peak at that time, conquered the world market. From the end of the century onwards, French instrument makers had to face strong competition from foreign industry (especially German, British and later American), nevertheless men like the Pellins and Jobin were able to modernize their companies and to continue a hundred-year-old tradition into the 20th century.

Today, many instruments made by Soleil, Duboscq and their successors survive in a number of museums and collections both in Europe and in the United States. Probably the largest collection of them can be seen in the *Musée du Conservatoire des Arts et Métiers* in Paris.

With this paper I conclude this series of articles dedicated to 19th century French instrument makers. In fact, many others could have been included in my research, but I do believe that I have been able to give a first overview of the development of the French precision industry during the most splendid period of its history. The SIS is planning to gather these articles (corrected and sometimes enlarged), as well as a detailed historical essay, in an illustrated bilingual volume (French and English), which I will complete next year.

Notes and References

1. I published a short article a few years ago on Soleil and their successors: 'Soleil Duboscq-Pellin: a Dynasty of Scientific Instrument Makers' in the *Proceedings of the 11th International Scientific Instrument Symposium*, edited by G. Dragoni, A. McConnell, and G. L'E. Turner (Bologna, 1994), pp. 107-111. See also the 1982 unpublished typescript by R. Sherman, 'The Soleil Family a Dynasty of Instrument makers as Members of the Scientific Community' which can be found (Doc. 900) at the *Centre de Documentation d'Histoire des Techniques (CDHT)* of the *Conservatoire des Arts et Métiers*. Many documents, letters, photographs and catalogues related to Soleil, Laurent, Duboscq and Pellin are kept in CDHT archives. I have to thank here Mme Dominique Deplace for her kindness during my search in this archives.

2. Until 1850, François Soleil was sometimes mentioned as 'Soleil *père*', while Jean Baptiste François Soleil was 'Soleil *fils*'. After that time, the latter one was known as 'Soleil *père*' and his son Henri 'became' 'Soleil *fils*'! In any case, the involvement of Jean Baptiste with the lighthouse technology was quite limited. This confusion is not recent (such as in the *Dictionary of Scientific Biographies*) but started in the late 19th century biographical and encyclopedic works such as *Vaporeau* and *Larousse*.

3. Most of the information concerning the co-operation between Fresnel and F. Soleil and their work can be found in: Augustin Fresnel, *Oeuvres Complètes*, edited by H. De Sénarmont, E. Verdet and L. Fresnel), vol. 3 (Paris, 1870). See also E. Allard, *Phares et balises*, vol. 5 of *Les travaux publiques de France*, edited by L. Reynaud (Paris, 1993; reprint Paris, 1995).

4. It is interesting to note that in the mosaic pavement of this elegant shopping arcade opened in 1826, there can still be seen the words 'M^son^ SOLEIL INGÉNIEUR OPTICIEN'. This advertisement near the door of a shop is probably the only surviving one of a Parisian instrument maker of the early 19th century.

5. See file F[12] 1021 in the National Archives of Paris. This instrument can still be seen in the collection of the *Conservatoire des Arts et Métiers*.

6. Around 1782, Aimé Argand (1755-1803) introduced a new kind of oil lamp with a

hollow cylindrical wick, which produced a more luminous and almost smokeless flame.

7. The idea was not completely new. In fact a polyzonal lens had been proposed by the French naturalist George Louis Leclerc de Buffon (1707-1788) in the mid-18th century.

8. The operation was referred to as *refouler le verre.* These terms are today not completely clear, but it seems that Soleil was remoulding the glass after having put it into an oven so that he could try to eliminate air bubbles and at the same time obtain a kind of glass ingot of a suitable size to be ground and polished.

9. See 'Instruments d'optique' in C. Laboulaye, *Dictionnaire des arts et manufactures, Complément*, 4th ed. (Paris, 1875).

10. A. Simpson, 'François Soleil, Andrew Ross and William Cookson: the Fresnel Lens applied', *Bulletin of Scientific Instrument Society,* No. 41 (1994) pp. 16-19 and also Sherman (*op.cit.*, note 1).

11. See Calla, 'Rapport sur l'établissement de M. François jeune, opticien', *Bulletin de la Société d'Encouragement pour l'Industrie nationale'*, 43 (1843), pp. 344-347.

12. The company became in 1890 *Sautter, Harlé & Cie* and then around 1910, *Harlé & Cie.* See Doc. 444 at the CDHT.

13. About J.B. Soleil's life see also Moigno's Introduction in his own work *Saccharimétrie optique, chimique et mélassimétrique* (Paris, 1869).

14. Palmer who specialized in stamping metal pipes invented a micrometric caliper with a vernier. This very common precision tool is still called a 'palmer' in both Italian and French. See 'Rapport fait par M. Alcan, sur la fabrication des tubes sans soudure, emboutis, par M. Palmer, méchanicien-tréfileur', *Bulletin de la Société d'Encouragement pour l'Industrie nationale,* 49 (1850), pp. 28-31.

15. Not all the instruments which are mentioned here were described by Soleil. The complete descriptions of many of them can be found in C. Chevalier and J. Fau, *Manuel du physicien préparateur,* Encyclopédie Roret (Paris, 1853) and in Ph. A. Daguin, *Traité élémentaire de physique,* Paris, 2nd ed. (1861-1862). For a recent work see P. Brenni, *Gli strumenti di fisica dell'Istituto Tecnico Toscano, Ottica* (Firenze, 1995).

16. 'Description de la cafetère atmopnumatique de M. Soleil', *Bulletin de ba Société d'Encouragement pour l'Industrie nationale,* 40 (1841), pp. 414-415.

17. J.B. Soleil, 'Nouveaux appareils pour la production des anneaux coloré à centre noir ou blanc', *Comptes Rendus de l'Académie des Sciences,* **18** (1844), pp. 417-419 and 782-782.

18. J.B. Soleil, 'Note sur la structure et la propriété rotatoire du quartz cristallisé', *Comptes Rendus d l'Académie des Sciences,* **20** (1845), pp. 435-438.

19. J.B. Soleil, 'Note sur un moyen de faciliter les expériences de polarisation rotatoire', *Comptes Rendus de l'Académie des Sciences,* **20** (1845), pp. 1805-1808.

20. J.B. Soleil, 'Nouvel appareil propre à la mesure des déviations dans les expériences de polarisation rotatoire', *Comptes Rendus de l'Académie des Sciences,* **21** (1845), pp. 426-430.

21. This device, thanks to the phenomena of chromatic polarization, made it possible to produce a very sensitive nuance of colour which suddenly changed with the slightest rotation of the plane of polarization of light. See J.B. Soleil, 'Note sur un perfectionnement apporté au pointage du saccharimètre', *Comptes Rendus de l'Académie des Sciences,* **24** (1847), pp. 973-975.

22. J. Babinet, 'Rapport sur le saccharimètre de M. Soleil', *Comptes Rendus de l'Académie des Sciences,* **26** (1848), pp. 162-168; 'Description du nouveau saccharimètre de M. Soleil, opticien', *Bulletin de la Société d'Encouragement pour l'Industrie nationale,* **45** (1846), pp. 543-549, and 'Rapport fait par M. de. Becquerel, un nom du comité des arts économiques, sur un saccharimètre présenté par M. Soleil', *Bulletin de la Société d'Encouragement pour l'Industrie nationale,* **46** (1847), pp. 545-552. See also Moigno (*op.cit.*, note 13).

23. J.B. Soleil, 'Notice sur l'horloge polaire de M. Wheatstone', *Comptes Rendus de l'Académie des Sciences,* **28** (1849), pp. 511-513; 'Sur l'horloge polaire de M. Wheatstone construit et perfectionné par M. Soleil', *Bulletin de la Société d'Encouragement pour l'Industrie nationale,* **48** (1849), pp. 371-373, and C. Wheatstone, 'On a means of determining the apparent Solar Time by the Diurnal Changes of the Plane of polarization at the North Pole of the Sky', *Report of The British Association for the Advancement of Science,* 1848, pp. 10-12.

24. J.B. Soleil, 'Nouvelle méthode pour l'emploi du mercure dans les operations de la photographie', *Comptes Rendus de l'Académie des Sciences,* **10** (1840), pp. 373-374 and 'Sur un moyen de déterminer le temps pendant lequel une plaque iodée doit rester exposée à la lumière pour donner une bonne image photographique', ibid., pp. 842-843.

25. J.F. Soleil, *Guide de l'amateur de photographie ou Exposé de la marche à suivre dans l'emploi du daguerreotype et des papiers photographiques* (Paris, 1840).

26. National Archives of Paris, 'Minutier des Notaires', Etude XLIV, 1020, 31.1.1850.

27. The small amount of money is only understandable by considering the fact that the buyers were the son and the son-in-law of the seller.

28. About Soleil's life and work see F. Moigno, 'Un fils qui ajoute à la gloire de son père-Verres et cristaux taillé pour l'optique de M. Henry Soleil', *Cosmos,* **7** (1855), pp. 504-507.

29. H. Soleil, 'Note sur la direction de l'axe optique dans le crystal de roche', *Comptes Rendus de l'Académie des Sciences,* **38** (1854), pp. 507-509; 'Sur un noveau télémètre décimal biréfringent', ibid., **40** (1855), pp. 434-436; 'Note sur quelques phénomènes oferts par la lumière polarisée circulairement. Nouvel appareil de polarisation circulaire et noveau compensateur', ibid., **40** (1855), pp. 1058-1060; 'Nouveau prisme biréfringent à quatre images', ibid., **41** (1855), pp. 408-409; 'Note sur un moyen nouveau de reconnaître si les faces, parallèles entre elles, d'une plaque de crystal de roche, sont aussi parallèles à l'axe du crystal ou inclinée dur cet axe', ibid., **41** (1855), pp. 669-671; 'Note sur l'échelle numérique des verres de lunette', ibid., **45** (1857), pp. 374-376; 'Note sur la déviation du plan de polarisation des couleurs résultantes dans une lame de quartz perpendiculaire à l'axe et traversée par un faisceau de lumière blance', ibid., **53** (1861), pp. 640-641.

30. See *'Prix Bordin* Rapport sur le concours de l'année 1865', *Comptes Rendus de l'Académie des Sciences,* **62** (1866), pp. 485-490; H. Soleil, 'Sur la direction de l'axe optique dans le cristal de roche', *Les Mondes,* **10** (1866), pp.662-668.

31. H. Soleil, 'Note sur une mesure de longueur invariable avec les changements de temperature', *Comptes Rendus de l'Académie des Sciences,* **69** (1869), p. 954.

32. About Laurent see in the National Archives of Paris, file F^{12} 5185 and F^{12} 3363.

33. A. Davis and U. Merzbach, 'The Rôle of the Polarimeter in the Diagnosis of Diabetes Mellitus. Biot's Bequest to 19th century Medical Saccharimetry', *Proceedings of the 11th International Scientific Instrument Symposium,* edited by G. Drangoni, A. McConnell and G. L'E. Turner (Bologna, 1994), pp. 143-151.

34. This important instrument is described in many articles, see for example, L. Laurent, 'Sur un nouveau saccharimètre et sur un moyen pour rendre le flamme de la soude absolument monochromatique', *Comptes Rendus de l'Académie des Sciences,* **78** (1874), pp. 349-351; 'Sur le saccharimètre Laurent', ibid., **89** (1879), pp. 665-666. See also D. Sidersky, *Polarisation et saccharimètrie* (Paris, 1895).

35. Among the apparatus invented or improved by Laurent, see L. Laurent, 'Appareil pour montrer le réfraction conique', *Journal de physique théorique et appliquée,* I série, **3** (1874), pp. 23-25; 'Nouveau saccharimètre', ibid., pp. 183-186; 'Miroir magiques en verre argenté', ibid., I série, **10** (1881), pp. 474-479; 'Appareil pour montrer et mesurer en projection, et simultanément, les plans de polarisation de l'analyseur et de la lame cristallisée', ibid., II série, **1** (1882), pp. 226-228 and 'Sur les appareils de projection à la lumière polarisée', *Comptes Rendus de l'Académie des Sciences,* **85** (1877), pp. 1162-1163; 'Sur le spectroscope de M. Thollon', ibid., **88** (1879), p. 82-84. Laurent also wrote 'Sur les lampes monochromatiques', ibid., **91** (1880), pp. 112-113; 'Miroirs magiques en verre argenté', ibid., **92** (1881), pp. 412-413, 712-713 and 874-875; 'Polarimètre à lumière ordinaire', ibid., **94** (1882), pp. 442-443 and 'Rapport fait par M. De Luynes, au nom du comité des arts économiques, sur les divers appareils présentés par M. Laurent, constructeur d'instruments de physique et de précision, rue de l'Odéon 21, a Paris', *Bulletin de la Société d'Encouragement pour l'Industrie nationale,* **78** (1879), pp. 426-428.

36. L. Laurent, 'Appareils d'optique destinés à controler les surfaces planes, parallèles, perpendiculaires et obliques', *Journal de physique théorique et appliquée,* II série, **2** (1883), pp. 411-418 (also in *Comptes rendus de l'Académie des Sciences,* **96** (1883), pp. 1035-1038) and 'Appareil pour contrôler les surfaces courbes sphériques ou cylindriques; objectifs, lentilles convergentes et divergentes; miroirs concaves et convexes; sphères', *Journal de physique théorique et appliquée,* II série, **4** (1885), pp. 361-366. All the apparatus were described in L. Laurent, 'Appareils et dispositifs pour le contrôle et l'exécution des surfaces optiques, planes et courbes à l'usage des instruments de

précision', *Bulletin de la Société d'Encouragement pour l'Industrie nationale* (1891), pp. 472-511.

37. L. Laurent, 'Sur l'orientation précise à la section principale des nicols dans les appareils de polarisation', *Comptes Rendus de l'Académie des Sciences*, **86** (1878), pp. 662-664; also L. Laurent, 'Méthode pratique pour l'exécution des prismes de Nicol et de Foucault', *Journal de physique théorique et appliquée'*, II série, **6** (1887), pp. 38-43, and 'Méthodes pratiques pour l'exécution des objectifs destinés aux instruments de précision', ibid., II série, **5** (1886), pp. 268-274. The last two articles were also published in the *Comptes rendus de l'Académie des Sciences*, **102** (1886), pp. 545-548 and 1012-1014.

38. See 'Dossier du comité secret du 2 novembre 1921', Archives of the Académie des Sciences.

39. In fact, the instruments signed 'Duboscq-Soleil' were made by Duboscq in the very first years of his independent activity.

40. About Duboscq's stereoscopes see 'Stéréoscope de M. Brewster, exécuté par M. Duboscq', *Comptes Rendus de l'Académie des Sciences*, **31** (1850), pp. 895-896; 'Nouveau stéréoscopes de M. Jules Duboscq', *Cosmos*, **1** (1852), pp. 703-705; F. Moigno, *Stéréoscope et ses effets merveilleux-pseudoscope et ses effets étranges* (Paris 1852); J. Duboscq, 'Note sur une nouvelle disposition de stéréoscopes avec prismes réfringents à angle variable, et lentilles mobiles', *Comptes Rendus de l'Académie des Sciences*, **44** (1857), pp. 148-150, also in *Cosmos*, **10** (1856), pp. 91-92.

41. See 'Rapport fait par M. Lissajous, au nom du comité des arts économiques sur les divers modèles de stéréoscopes presentés par M. Duboscq opticien', *Bulletin de la Société d'Encouragement pour l'Industrie nationale*, **56** (1857), pp. 707-720.

42. See specially J.E. Buerger, *French Daguerreotypes* (Chicago & London, 1989), and J.M. Eder, *History of Photography* (New York, 1945, reprint 1978).

43. J. Duboscq and E. Robiquet, 'Note sur le collodion sec', *Comptes Rendus de l'Académie des Sciences*, **43** (1856), pp. 1194-1196. See also J. Duboscq, 'Note sur le photographomètre de M. Chevallier', *Comptes Rendus de l'Académie des Sciences*, **64** (1867), pp. 573-574; 'Rapport sur la planchette photographique inventée par M. Chevallier, et costruite par M. Duboscq', *Comptes Rendus de l'Académie des Sciences*, **68** (1869), pp. 852-856.

44. Buerger (*op.cit.*, note 42), G. Turpin, 'L'image animée: les année Duboscq', *La Cinémathèque française*, **19** (1987), pp. 10-14 and L. Mannon, *Le grand art de la lumière et de l'ombre-archéologie du cinéma* (Paris, 1994, pp. 215-217).

45. Later other projection apparatus of moving images, which were completely different to Duboscq's one, were baptised 'bioscopes'.

46. See for example Th. Du Moncel, *Projection des phénomènes d'optique à l'aide des appareils de M. Duboscq* (Paris, 1855); J. Bertin, 'Notice sur la projection des expériences de polarisation', *Journal de physique théorique et appliquée*, I série, **4** (1875), pp. 72-84 and 111-120; J. Bertin, 'Sur l'appareil redresseur de M. Duboscq', *Comptes Rendus de l'Académie des Sciences*, **8** (1879), pp. 336-341; J. Bertin and J. Duboscq, 'Note sur les miroirs magiques', *Journal de physique théorique et appliquée*, I série, **9** (1880), pp. 401-407; J. Bertin, 'Rapport présenté au nom du comité des arts économiques sur les inventions de M. Jules Duboscq', *Bulletin de la Société d'Encouragement de l'Industrie nationale* (1882), pp. 66-68.

47. See the archives of the CDHT.

48. J. Duboscq, 'Note sur un régulateur électrique', *Comptes Rendus de l'Académie des Sciences*, **31** (1850), pp. 807-809, and J. Duboscq, 'Note sur une nouvelle disposition de la lampe photoélectrique', *Comptes Rendus de l'Académie des Sciences*, **54** (1862), p. 741; E. Saint-Edme, 'Nouveau régulateur de M. Léon Foucault, construit par M.J. Duboscq', *Cosmos*, **24** (1864), pp. 121-126; J.A. Lissajous, 'Communication sur le régulateur de lumière électrique de M. Foucault modifié par M. Duboscq', *Bulletin de la Société d'Encouragement pour l'Industrie nationale* (1868), pp. 59-60.

49. J. Duboscq, 'Sur un héliostat nouveau', *Comptes Rendus de l'Académie des Sciences*, **54** (1862), pp. 618-620 and J. Duboscq, 'Note sur un héliostat de grande dimension', ibid., **55** (1862), pp. 644-645.

50. J. Duboscq and C. Mène, 'Nouveau colorimètre pour l'analyse des matrières tinctorials au point de vue commercial', *Comptes Rendus de l'Académie des Sciences*, **67** (1868), pp. 1330-1331, and 'Jules Duboscq soumet au jugement ...', *Les Mondes*, **18** (1868), pp. 755-757.

51. J. Duboscq, 'Appareil pour la projection des corps placé horizontalement', *Journal de physique théorique et appliquée*, I série, **5** (1876), pp. 216-218; J. Duboscq, 'Galvanomètre transparent à projection', ibid., pp. 218-219; J. Duboscq, 'Expériences de projection ou l'on utilise la pérsistence des impressions sur la rétine', ibid., I série, **6** (1877), pp. 213-216; J. Duboscq and Parinaud, 'Appareil destiné à l'étude des intensité lumineuses et chromatiques des couleurs spectrales et de leur mélanges', ibid., II serie, **4** (1885), pp. 271-273.

52. J. Duboscq and H. Soleil, 'Note sur un nouveau compensateur pour sacchrimètre', *Comptes Rendus de l'Académie des Sciences*, **31** (1850), p. 248-250.

53. Soleil, Duboscq and their successors printed several catalogues and a large number of special instruction leaflets for their instruments. Several of them can be found in the CDHT. Of particular interest is J. Duboscq, *Historique et catalogue de tous les instruments d'optique supérieure appliqués aux sciences et à l'industrie* (Paris, 1885). In this catalogue Duboscq specified that all the 454 mentioned instruments were made in his own workshop.

54. See for example H. Tresca, 'Compte rendu de la soirée scientifique du 29 octobre 1864 au Conservatoire des Arts et Métiers', *Annales du Conservatoir Impérial des Arts et Métiers*, **5** (1864), pp. 259-288 or F. Moigno, 'Une conférence au Palais des Tuileries', *Les Mondes*, **10** (1867), pp. 361-364. See also R. Fox, 'Les conférences mondaines sous le Second Empire', *Romantisme*, **65** (1989).

55. G. Tissandier, 'La science au nouvel oper III La lumière électrique', *La Nature*, I ser (1875), pp. 150-154.

56. The articles describing this apparat appeared in the years 1863-1864 in *Cosm* and they finally formed a special bookle catalogue. See J. Duboscq, *Catalogue appareils employés pour la production des phén mène physique au théâtre* (Paris, 1877) and al A. de Vaulabelle and C. Hemardinquier, *I science au théâtre. Étude sur les procéd scientifiques en usage dans le théâtre moder* (Paris, 1908).

57. We can only list here Paris (1855, 186 1878), London (1851, 1862, 1872), New Yo 1853, Vienna 1873, Philadelphia 1876, An sterdam 1883, but Duboscq also participated minor or specialised exhibitions.

58. National Archives in Paris, 'Minutier d Notaires', étude CVI, 1031, 28.7.1879.

59. Albert wrote a few articles: A. Dubosc 'Support universel ou électrodiapason perme tant d'inscrire et montrer en projection l mouvements vibratoires', *Journal de physiq théorique et appliquée*, I série, **8** (1879), pp. 60-6 See also Stiegler, 'L'enseignement par l projections', *La Nature* (1879), II sem., p 367-370, and Stiegler, 'L'acoustique en proje tion', ibid. (1880), I sem., pp. 403-406.

60. See for example Th. and A. Dubosc 'Saccharimètre à franges et à lumière blanche *Journal de physique théorique et appliquée*, II séri **5** (1886), pp. 274-277.

61. See National Archives in Paris, 'Minuti des Notaires', étude CVI, 1069, .7.1885.

62. Most of the information concernin Philibért Pellin and his son Félix can be foun in the files LH 2087/75 and LH 2087/74 of th *Légion d'honneur* in the National Archives Paris.

63. Ph. Pellin, 'Refractomètre de M. Dupré *Journal de Physique théorique et appliqué*, II séri **8** (1889), pp. 411-415; Ph. Pellin, 'Spectroscop à deviation fixe', ibid., III série, **8** (1899 pp. 314-319; Ph. Pellin, 'Polarimètres saccharimètres', ibid., IV série, **2** (1903 pp. 436-442. In the same journal Félix Pelli published with C. Tissot, 'Correction d l'astigmatisme des prismes birifringents', ibid IV série, **7** (1908), pp. 296-289; and 'Réceptio des signaux horaires radiotélégraphiques ibid., IV série, **8** (1909), pp. 117-118.

64. Pellin participated in the following e hibitions: Antwerp 1885 (together with D boscq), Le Havre 1887, Barcelona 1888, Par 1889, Moscow 1891 (*hors concours*), Chicag 1883 (*hors concours*), Amsterdam 1895, Brusse 1897 (*hors concours* member of the jury), Par 1900 (member of the *comité d'installation*), Louis 1904, Liège 1905, Milan 1906, Londo 1908 (*hors concours*), Brussels 1910, Turin 191 Gand 1913. The presence at the exhibitior continued after World War I.

65. See 'Medaille d'or à M. Pellin', *Bulletin la Société d'Encouragement pour l'Industr nationale*, **89** (1890), pp. 543-544.

66. See CDHT, Doc. 3069.

67. See CDHT, Doc. 3029.