C. R. Geoscience 347 (2015) 105–111

Contents lists available at ScienceDirect

Comptes Rendus Geoscience

www.sciencedirect.com

History of Sciences

The material conditions for research in France from 1600 to 1850: Physics, chemistry and astronomy

James Lequeux

LERMA, Observatoire de Paris, and Université Pierre et Marie Curie, 61, avenue de l'Observatoire, 75014 Paris, France

ARTICLE INFO

Article history:
Received 19 January 2015
Accepted after revision 3 February 2015
Available online 26 May 2015

Handled by V. Courtillot

Keywords:
History of sciences
17–19th centuries
Costs
Big projects
Paris Observatory

ABSTRACT

The income of the scientists in France during the 17th to the middle of the 19th century is reviewed and compared to the cost of their instruments. Only a small number of scientists received enough public money to be able to do full-time research; this number increased substantially after the Revolution. Most scientists had to have other sources of income, in particular to be able to purchase their instruments. Large research projects, generally decided and financed by the Academy of Sciences, took place during this period, requiring collaborative interdisciplinary efforts and a considerable logistics: they anticipate our present cooperative programs and giant research facilities.
© 2015 Académie des sciences. Published by Elsevier Masson SAS. All rights reserved.

1. Introduction

Curiously, the material conditions for scientific research in the past centuries have been little explored. How the scientists made their living and how they purchased their instruments, how their research was triggered by external events and in which context it was made, these are topics which are certainly much less known than the discoveries themselves. I aim at starting to fill this gap, but only for a period limited in time and space, and for physics, chemistry, and astronomy only. Natural sciences would deserve another study.

A major difficulty in this kind of study is to obtain the equivalence of the ancient moneys to our euros. The only possible way is to rely on the cost of living, through the prices of basic items, like bread, milk, housing, salaries of domestic personnel, newspapers, books, etc. However, the way of living in the past was so different from the present one that the comparison is of limited value. For the 17th century and the first half of the 18th century, I adopt 1 *livre* (£) = 5.5 euros. There was a strong devaluation in France in the 1770–1780s, so that for the end of the 18th century and the first half of 19th century, I adopt the equivalence 1 £ = 1 franc (F) = 3.5 euros, using essentially the data of Table 2.1 in Tobin (2002). The franc replaced the *livre* during the Revolution, with almost exactly the same value. I must stress that these equivalences are indicative only and must be used with much caution.

2. Salaries in the 17th and 18th centuries

During this period, the only public institution for research in France in our domain was the Academy of Sciences, founded in 1666 (Maury, 1864). The Paris Observatory, founded the following year, depended on the Academy and was financed on the Royal treasure (Wolf, 1902). In order to attract renowned scientists from abroad, they were given relatively high salaries: Huygens received 6000 £ per year and Cassini 9000 £ (equivalent to 50,000 €). Roemer obtained 1000 £/year when he came to Paris in 1672, a sum increased progressively to reach 4200 £ (23,000 €) per year in 1680, at the end of his stay in Paris "in view of his astronomical discoveries". The other

E-mail address: james.lequeux@obspm.fr.

http://dx.doi.org/10.1016/j.crte.2015.02.011
1631-0713/© 2015 Académie des sciences. Published by Elsevier Masson SAS. All rights reserved.

academicians received in principle 1200 £/year, then 1500 £ (8250 €) in 1669. This was not much and the money came irregularly, probably by purpose because the government did not want that this became an automatic subvention; but most scientists had other sources of income, and they were often housed for free at the Observatory or other places. Unfortunately, all the salaries decreased at the end of the 17th century, and again at the beginning of the 18th century, due to the difficult financial situation of France: the director of the Observatory received only 2700 £ in 1771, an amount which remained the same until 1789 in spite of devaluations: the history of the Observatory in the 18th century is that of a long decay. As to the members of the Academy, their annuity was variable. For example, Abbé La Caille received only 500 £/year when he returned in 1754 from his long travel in the southern hemisphere, which made him famous (Glass, 2012). This added to his meagre salary of 600 £/year as a professor of mathematics at the Collège des Quatre-Nations, and to the income from his books. He was housed for free in the Collège. His biographer Carlier wrote: "The academies are the chivalry orders of the Republic of Arts: one usually gathers more honours than money".

Following the reform of the Academy of Sciences in 1699 (Tits-Dieuaide, 1998), the number of academicians was fixed to 70, including 20 *pensionnaires* with an annual salary of about 2400 £ (13,000 €) and the help of a technician paid by the Academy. They had some duties in exchange, in particular the secretary and the treasurer.

The prizes or *encouragements* distributed by the Academy of Sciences could provide some extra income. They were very oriented towards practical problems: over the 62 prizes awarded between 1720 and 1772, 26 concerned sailing, 5 longitudes, 15 astronomy and celestial mechanics, 10 physics and 6 various topics. Surprisingly, a few scientists obtained most of the prizes: Euler got 22 of them, Jean and Daniel Bernoulli 16, Bouguer 4, Lagrange and Abbé Bossut 3 each. Consequently, they were of little help for the other scientists.

The salaries of the small personnel were much lower than those of the established scientists, but more stable because it was really difficult to make them smaller. When La Caille entered the Paris Observatory in 1732, he was paid 600 £/year. The *aides astronomes* created the following year received annually only 360 £ (2000 €). At the end of the 18th century the three *élèves astronomes* obtained from 600 to 900 £/year, a sum raised to 1000 £ (3500 €) per year during the Revolution. The porter and the concierge-treasurer of the Observatory had annual salaries of only 200 and 500 £ respectively in the 17th century, plus some advantages. The salary of the concierge was raised to 800 £ in 1776, reflecting the devaluation of the money. These salaries were comparable to that of an ordinary workman.

It is likely that from 1660 or so to the Revolution at the end of the 18th century there were in France no more than 30 physicists, chemists and astronomers (including those of the observatories in Marseilles, Toulouse and the "École militaire" in Paris, created respectively in 1702, 1733 and 1780), who received a reasonably good salary from public establishments, allowing them to do more or less full-time research. The others had to find other sources of income, for example as professors in the "Collèges", which were either parts of the Paris University or independent.

3. Salaries in the 19th century

The situation was to improve considerably during the Revolution, thanks to the creation of new entities (for more detailed information, see Lequeux, 2008). Following the "École royale du génie de Mézières" (School of military engineering) founded in 1748, the "École polytechnique" was created in 1794. Its professors were paid 9700 francs (34,000 €) per year, and the adjunct professors 3000 F. The same year, the "Bureau des longitudes" (Board of longitudes) was also founded, to cover the whole astronomy in France. It had 10 full members, paid initially 8000 £ (28,000 €) annually, and an increasing number of adjunct members paid 4000 £/year, "a sufficient salary for a modest living". The Board also paid a number of lower-grade people, with a minimum annual salary of 1500 £/year, comparable to the lowest salaries of scientists in the 18th century. The salaries of the university professors were similar to those of the professors at the "École polytechnique". As to the members of the Academy (which was suppressed in 1793 and re-created two years later as the "Première classe de l'Institut", then again as the "Académie royale des sciences" in 1816), they received 1200 F/year. It was possible to cumulate: for example, François Arago in 1830 got annually 6000 F from the Academy as its Perpetual Secretary, 6500 F as a member of the Board of longitudes, and 3800 F as an examiner of the students of the "École d'artillerie de Metz", which succeeded the school of engineering of Mézières mentioned previously. He had resigned from his position of Professor at the Polytechnic school, but he still got a comfortable total of 16,300 F (57,000 €) per year. With such a salary, it was possible to buy some instruments for research, as did Arago who purchased personally several instruments, now preserved at the Paris Observatory to which they were given by his niece.

The prizes given by the Academy were more varied and more evenly distributed than during the preceding century and were certainly more efficient to stimulate research. As a consequence of these changes, there were more scientists paid on public funds than before, and they were often better paid.

However, the wages of workmen and domestic personnel were still extremely low: an average of 700 F per year (2 F by working day, while the cost of one kilogram of bread was 0.45 F), raised progressively to 1000 F in 1850. This was lower than the minimum salaries at the Observatory or in other public institutions, which were of the order of 1500 F, as we have seen.

4. The instruments of research

The following table gives prices for a selection of instruments. They come from reliable references, in particular prices from catalogues of instrument builders or dealers. All these catalogues are available via http://cnum.cnam.fr.

Instrument	Date	Price (£ or F)	Equivalent (€)	Reference
Picard's quadrant	1683	400	2200	Wolf (1902)
*Telescope 34 ft length	ca. 1680	3000	16,500	Wolf (1902)
Average Italian lens (objective of telescope)	ca. 1680	150	800	Wolf (1902)
*Mural quadrant	1732	2154	5500	Wolf (1902)
Nollet's pair of globes	1733	335	1850	Cath. Hofmann, priv. comm.
Pneumatic machine	1739	600	3300	Musschenbroek catalogue[a]
Microscope	1739	100	550	Musschenbroek catalogue
La Caille's sextant	1750	2000	11,000	Glass (2012)[b]
*Dollond's reflecting telescope, 18 cm diameter	1787	6000	21,000	Wolf (1902)
Astronomical clock	1788	1240	4300	Wolf (1902)
Pair of globes	1815	400	1400	Delamarche catalogue
*Gambey's meridian telescope, diameter 15 cm	1834	12,000	42,000	Lequeux (2008)
Achromatic microscope	1844	300	1050	Buron catalogue
Electrostatic machine	1845	1200	4200	Pixii catalogue
Pixii's magneto	1845	600	2100	Pixii catalogue
Arago's polarimeter	1848	100	350	Deleuil catalogue
High-precision scale	1848	1000	3500	Deleuil catalogue
Repeating theodolite	1850	3000	10,000	Secrétan catalogue
16-cm diameter equatorial	1850	9000	32,000	Secrétan catalogue
Fizeau's velocity of light apparatus	1855	5500	19,000	Froment's manuscript (for 1855 exhibition)
Silbermann's heliostat	1860	500	1750	Chevalier catalogue

[a] The catalogue of van Musschenbroek (s.d. but actually 1739) gives prices in Dutch *florins* (gulden), with a change value of 2 *livres* per *florin*: see Glass (2012) p. 32.

[b] The price is given in *louis d'or*, for which Glass (2012), p. 170, gives erroneously the later value of 24 *livres*. The actual value at the time of La Caille was 10 *livres*.

To build this table, I have selected the best-quality instruments, because it is clear that they were necessary for research. Some of the most expensive ones, marked by an asterisk, were purchased for the Paris Observatory and were completely out of reach of individuals. The high prices of all these instruments are easy to understand because they were made almost entirely by hand, the only available machines being the lathe and the machine to divide circles. The quality of the best surviving instruments is astounding, and it is notoriously difficult at present to find people sufficiently skilled to repair or to copy them. In order to see which instruments were necessary for research by isolated scientists, in laboratories and for teaching, one should look at catalogues: for the 18th century that of van Musschenbroek (s.d., but actually 1739) or that of Nollet (1738), and for the 19th century any of the catalogues cited in the table.

If one compares the prices of these instruments with the salaries of scientists described in the preceding sections, it is clear that most of them could not afford these instruments, unless they had extra sources of income. La Caille provides a good example. He benefited from a well-equipped observatory paid by the "Collège des Quatre-Nations" and located on the roof of this College (the building survives and is presently the seat of the Academies, but the observatory has disappeared). But when he was sent by the Academy of Sciences to Cape Town to map the southern sky, he did not have an accurate instrument. Fortunately, he received from the Minister an extra subsidy of 200 *louis d'or* (2000 £) to cover his own expenses: he used it to buy a superb sextant, which enabled him to measure the positions of the southern stars, and of the northern stars at his return, with a remarkable accuracy. He would never have been able to obtain this result without this extra money.

In the 18th century, most of the instruments on sale were purchased by rich amateurs, who had their own observatory or physics cabinet. Here are some famous examples:

- the cabinet of Reaumur (1683–1757), where Nollet began instrument building and researches as an employee (ca. 1720);
- the private observatory of Le Monnier (1715–1799), who received important subsidies from the king (ca. 1740). It

was the best equipped of Paris, much better than the Paris Observatory itself;
- the cabinet of Buffon (1707–1788) in Montbard (ca. 1740);
- the private observatory of Delisle (1688–1768) at the "Hôtel de Cluny" (presently "Musée du Moyen Âge"), where he had Lalande and Messier as employees. Delisle made a fortune in Russia, which allowed him to create his observatory in 1747;
- the private observatory and physics cabinet of King Louis XV (ca. 1760), located at Passy near Paris. It contained remarkable instruments, in particular the largest-diameter telescope of the time (Fig. 1); but very few scientific results came out of them;
- the cabinet of Trudaine de Montigny (1733–1777), who was *intendant général des finances* and consequently very wealthy (ca. 1760);
- the cabinet of Lavoisier (1743–1794), who was also very rich as one of the *fermiers généraux* who collected taxes... and kept a part for themselves. His magnificent chemistry laboratory (ca. 1770) is on display at the "Musée des Arts et Métiers/CNAM".

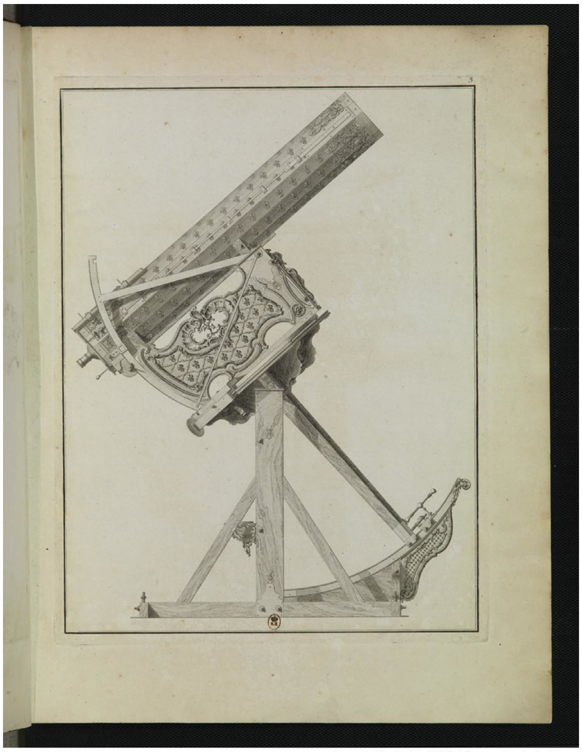
Source gallica.bnf.fr / Bibliothèque nationale de France

Fig. 1. The large reflecting telescope of King Louis XV in Passy. Built by Dom Noël (1712–1780) in 1772, this Cassegrain telescope had a 61-cm diameter brass mirror and a length of 6.3 m. This was the largest telescope in the world until those of Herschel. Its value was estimated by Lalande as 500 000 F (1,75 M€) (Lalande, 1800). It was transported to the Paris Observatory around 1800 with a new mirror and a new mount, but it was so cumbersome that it did not produce any result and was dismantled in 1841.
Bibliothèque nationale de France.

Most of these cabinets were dismantled at the Revolution, and research became essentially public. However, some 19th century scientists used to work at home and purchased their own instruments: so was Berthollet who had his own laboratory in Arcueil near Paris, Foucault (1819–1868) (Tobin, 2003) before he entered the Paris Observatory as the Observatory physicist in 1855, and also Fizeau (1819–1896) (Lequeux, 2014).

5. Towards big and collective science

During the first half of the 17th century, research was essentially done by single individuals; however, they were not scientifically isolated, thanks to the enormous quantity of letters they exchanged and to their frequent meetings. However, collaborative or coordinated work started slowly. The first example of importance is the ensemble of simultaneous observations of the total eclipse of Moon on 28 August 1635, organized by Nicolas Claude Fabri de Peiresc (1580–1637) in twelve different places around the Mediterranean Sea. He asked colleagues to obtain the local sidereal time at these places, and to note the sidereal time of the beginning of the eclipse. Later, these times were compared: the difference between the local times of the event gave directly the difference of longitude. As a result of this remarkable work, the east–west length of the sea was reduced by 1000 km!

This was followed by small scientific expeditions. In 1671, Picard was sent to Denmark in order to determine the longitude difference between Uraniborg, the ancient observatory of Tycho Brahe, and the Paris Observatory. In 1672–1673, Richer was in Cayenne to observe the position of Mars with respect to distant stars, while Cassini was doing the same observation in Paris: the parallax of Mars was measured in this way, hence, for the first time, the dimensions of the Solar system. Between 1676 and 1681, Picard and La Hire went to different harbours in France to measure their coordinates; this resulted in a diminution by 10% of the east–west extent of France. Less known is the trip of Varin, Deshayes and de Glos to Gorée in Senegal and to the West Indies (1681–1683) (Dew, 2010). All these expeditions were financed quite correctly by the Academy.

At the same period, there was a collaborative effort at the Paris Observatory in order to observe and predict the eclipses of Jupiter's satellites in the shadow of the planet. These eclipses, more frequent and more definite than lunar eclipses, gave the time references necessary for the determinations of longitude. Cassini, Picard, La Hire and Roemer all took part in these observations.

However, the main activities of the astronomers of the Observatory were geodesy and map-making. The number and the extent of the triangulations they made not only in France, but also in Peru, in Lapland and in South Africa from 1669 to the end of the 18th century are astonishing. These operations, which were decided and organized by the Academy, required a good preparation and a lot of money: for example, Cassini received in 1683 3000 £ (16,500 €), La Hire 2000 £, and the other observers 600 £ for the sole field reconnaissance for the measurement of the meridian from Paris to Dunkirk. Their logistics was often as complex as that of our modern collaborative programmes. The most demanding were certainly the overseas scientific expeditions of Bougainville (1766–1769), La Pérouse (1785–1788), Freycinet (1817–1820), Duperrey (1822–1825) and Dumont d'Urville (1826–1829 and 1837–1840). As discussed in detail by Debyser (2007), science was entering progressively into a new phase with these big projects, for which collaborations between scientists of different origins and specialties were necessary. Already, some of the triangulations had gathered not only astronomers from the Paris Observatory and from elsewhere, but also physicists, zoologists and botanists. This became the rule for the overseas explorations.

6. Big projects

The first big project devoted to science in France was the Paris Observatory, founded in 1667. This "Citadel of sciences" was originally conceived not only as an Observatory, but also as a meeting place for the members of the Academy of Sciences and as a repository for their collections. It was considered by them too far from the centre of the city and remained entirely devoted to Astronomy. The cost of this magnificent building amounted to 714,000 £, to which should be added the cost of the ground-plot (6604 £) and of the surrounding wall (18,500 £): a total of 739,104 £, approximately equivalent to 4 M€. This does not include the equipment, which amounted to a total of 38,039 £ (210,000 €).

I have already mentioned the large telescope of Louis XV (1772). Another contemporary big project, comparable to our present accelerators or synchrotrons, was the large "ardent lens" (Fig. 2) financed by Trudaine de Montigny in 1774 (Trudaine de Montigny et al., 1774). I have not been able to find the cost of this instrument, but it must have been very high. For comparison, two large "ardent mirrors" were paid 7000 and 9000 £ respectively in the 1680s. Trudaine's lens was much more sophisticated and certainly much more expensive. Lavoisier and others used this lens to study the fusion of various bodies and for chemistry experiments, until Lavoisier invented the oxyhydrogen torch, which was more convenient and allowed to reach even higher temperatures.

Another big instrument was the great electric battery offered in 1808 by Napoléon to the Polytechnic school (Fig. 3); Gay-Lussac and Thénard (1811) used it for various chemistry and physics experiments, particularly electrolyses.

Finally, I mention the 38-cm diameter equatorial built mid-19th century at the Paris Observatory (Fig. 4). Its rotating dome was the largest in the world, and the equatorial should have been the equivalent of the ones in Pulkovo (Russia) and in Harvard, built respectively in 1838 and 1847. The dome required a large amount of masonry and ironwork, for the considerable total of 480,000 F (equivalent to 1.7 M€), while the cost of the telescope itself was 130,000 F (450,000 €). Unfortunately the objective was damaged and the instrument could only be used after a new one was installed in 1881.

Although only partly scientific, the construction of the map of France by Cassini de Thury (Cassini III) and his son Cassini IV should be mentioned as an enormous project (Pelletier, 2013). Based on the previous triangulations, it extended from 1747 to 1787, for an estimated total cost of 800,000 £. It was financed by a private society with parts, initially with 50 associates, and by contributions of the French *provinces* (states). The subscribers were supposed

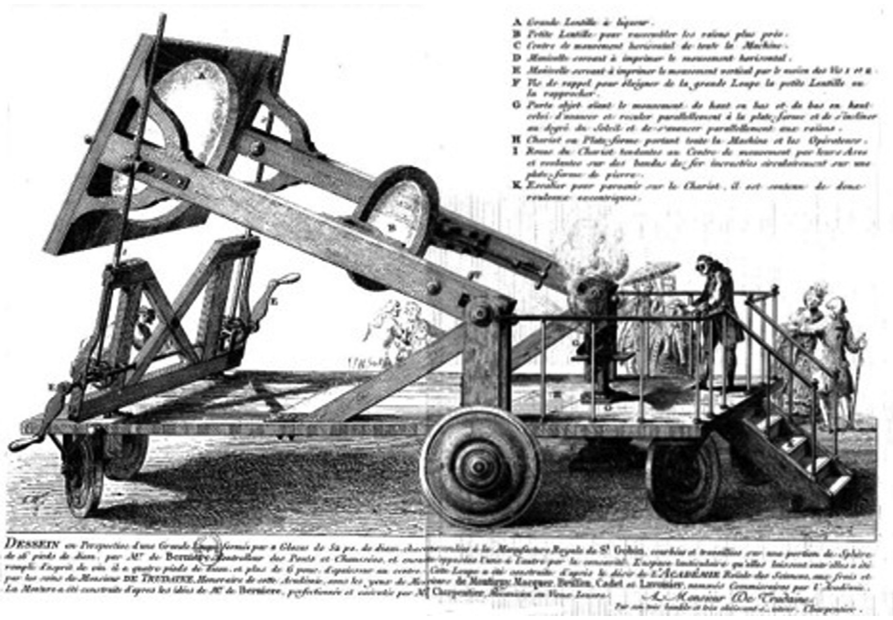

Fig. 2. The ardent lens of Trudaine de Montigny (1774), engraving in *Œuvres de Lavoisier*, 1862. The primary lens **A**, with a diameter of 130 cm, was made of two curved glass plates with ethyl alcohol in between. A secondary glass lens **B** shortened the focal length. The concentrated solar light was used for physics and chemistry experiments
Bibliothèque nationale de France.

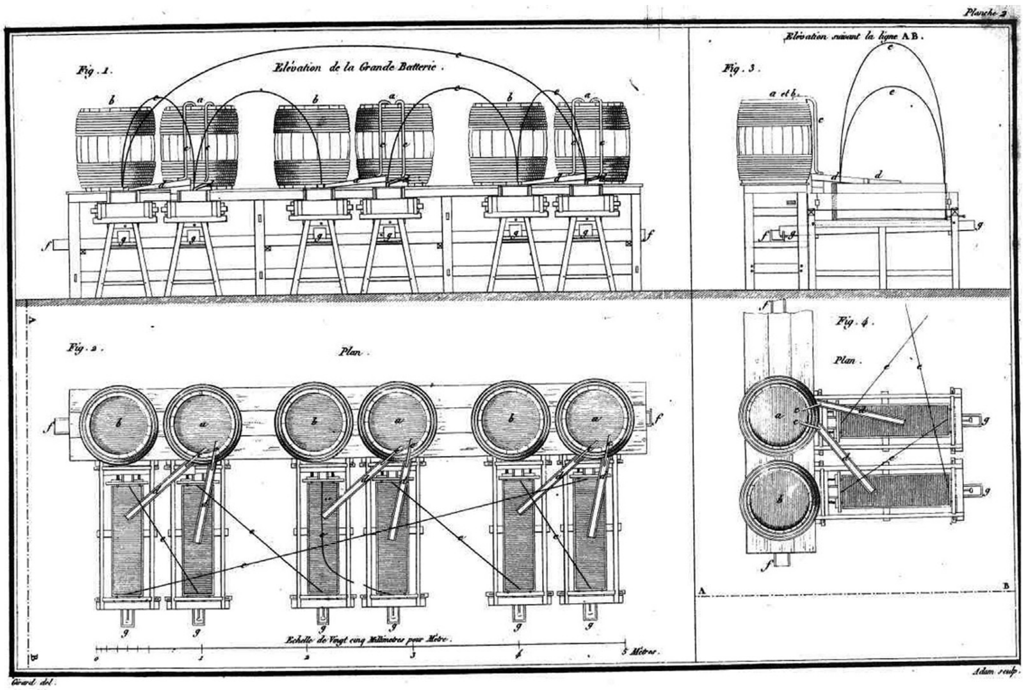

Fig. 3. The large battery installed in 1808 by Gay-Lussac and Thénard at the Polytechnic school. It consisted of 6 wooden containers with 100 pairs of plates each. The surface of the plates was 9 square decimetres. Each pair was made of a copper plate weighting 1 kilogram, and a zinc plate of 3 kilograms. The platinum conductors connecting each container to the next one are visible. The barrels contained an acid solution to be poured in the containers, or water to rinse them after draining. The battery could supply about 10 amperes under 660 volts.
Cnum/Conservatoire des Arts et Métiers, Paris (http://cnum.cnam.fr).

to be reimbursed from the sales of the prints of the map. For this, subscriptions were organized. This worked relatively well until the Revolution; then the society was nationalized and the subscribers were only partly reimbursed. Overall, the Cassini's map was a great success and one is struck with admiration by its beauty and accuracy.

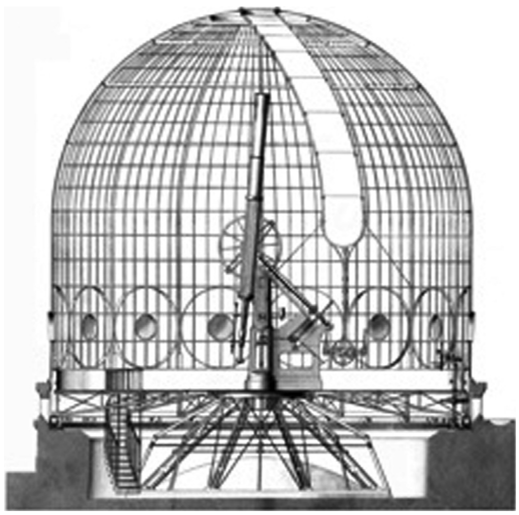

Fig. 4. The dome and the 38-cm equatorial of the Paris Observatory. Built by the architect de Gisors and the engineer Travers, the rotating dome was the largest of the time. The telescope, built by Brunner, is supported by a curious metallic spider resting on the walls of the tower: no central pillar was possible.
From Arago's *Astronomie populaire, author's collection.*

7. Conclusion

There was a continuous evolution from the science of the beginning of the 17th century, which was essentially the fact of rich private individuals, to that of the 19th century, more public and more collective. The Encyclopaedists certainly played a role in this evolution, by creating a large movement to promote science and technique, but only for a restricted elite, that which attended the experiments in the physics cabinets. The Revolution did not bring fundamental changes in the way of doing science: but it became more democratic and public, and possibilities of doing research were offered to more people. However, it was still good to be wealthy because of the high cost of the instruments, as shown by the examples of Foucault and Fizeau.

The 18th century saw a remarkable development of coordinated researches and of big projects, a trend initiated during the preceding century. They were generally decided and financed by the Academy of Sciences, which was at the centre of all French science. Public research centres, properly speaking, appeared at the beginning of the 19th century, but the first public laboratory identified as such was only founded in 1851: that of Sainte-Claire Deville at the "École normale supérieure".

At all times, science was international. There was no condition of citizenship to enter the Academy or to receive prizes. French scientists were always aware of what happened in other countries, and vice versa. It is remarkable that the scientific exchanges between France and foreign countries were completely ignorant of the conflicts and wars: they were only made more difficult.

The period I have considered was the most glorious of French science. In spite of the sustained interest of the public, physics, astronomy and chemistry lost ground after 1850 compared to what occurred in England, in Germany and in the USA. The reasons for this remain to be studied in depth, although the conservatism of the University and an excessive emphasis on technique and applications were certainly amongst the causes. The difficult renewal of science in our country took place only after World War 2 (see for example the remarkable testimony of Anatole Abragam, 2000).

Acknowledgements

This is an invited contribution to the special issue "Invited contributions of 2014 geosciences laureates of the French Academy of Sciences". I thank Jean-Paul Poirier and Vincent Courtillot for their careful review of this paper.

References

Abragam, A., 2000. De la physique avant toute chose ? Odile Jacob, Paris.
Debyser, J., 2007. Un nouveau regard sur la nature : temps, espace et matière au siècle des Lumières. Observatoire de Paris & EDP Sciences, Paris.
Dew, N., 2010. Scientific travel in the Atlantic world: the French expedition to Gorée and the Antilles (1681–1683). Br. J. Hist. Sci. 43 (1), 1–17 accessible via http://journals.cambridge.org/action/displayAbstract?aid=7332760.
Glass, I.S., 2012. Nicolas-Louis de La Caille, Astronomer and Geodesist. Oxford University Press, Observatoire de Paris & EDP Sciences, Paris (French translation by J. Lequeux (2013)).
Gay-Lussac, L.J., Thénard, L.J., 1811. Recherches physico-chimiques, faites sur la pile, tome 1Deterville, Paris, pp. 1–7 accessible via http://cnum.cnam.fr.
Lalande, J., 1800. Histoire de l'Astronomie pour l'an VIII. In: Connaissance des temps pour 1805. 253–255 accessible via http://gallica.bnf.fr.
Lequeux, J., 2008. François Arago, un savant généreux. Observatoire de Paris & EDP Sciences, Paris.
Lequeux, J., 2014. Hippolyte Fizeau, physicien de la lumière. EDP Sciences, Les Ulis, France.
Maury, L.F.A., 1864. L'ancienne Académie des sciences. Didier, Paris accessible via http://gallica.bnf.fr.
Nollet, Abbé, 1738. Programme ou idée générale d'un cours de physique expérimentale avec un Catalogue raisonné des Instrumens qui servent aux expériences. Le Mercier, Paris accessible via http://gallica.bnf.fr.
Pelletier, M., 2013. Les cartes de Cassini : la science au service de l'État et des provinces. Éditions du CTHS, Paris.
Tits-Dieuaide, M.J., 1998. Les savants, la Société de l'Etat : à propos du « renouvellement » de l'Académie royale des sciences. Journal des savants 1, 79–114 accessible via http://www.persee.fr/web/revues/home/prescript/article/jds_0021-8103_1998_num_1_1_1615.
Tobin, W., 2003. Léon Foucault. Cambridge University Press, Les Ulis, EDP Sciences, Cambridge, UK (French translation by Lequeux, J.).
Trudaine de Montigny, Macquer, Cadet, Lavoisier, Brisson, 1774. Premier essai du grand verre ardent de M. Trudaine. Mémoires de l'Académie royale des sciences pour 1774. 62–72 accessible via http://gallica.bnf.fr.
Van Musschenbroek, J., 1739. Liste des diverses machines de physique, de mathématiques, d'anatomie et de chirurgie qui se trouvent chez Jean van Musschenbroek à Leyden, Leyde, s.n. accessible via http://cnum.cnam.fr.
Wolf, C., 1902. Histoire de l'Observatoire de Paris de sa fondation à 1793. Gauthier-Villars, Paris accessible via https://openlibrary.org/books/OL15216194M/Histoire_de_l'Observatoire_de_Paris_de_sa_fondation_a_1793.