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THE ROLE OF THE CONFERENCES AND THE *BULLETIN* IN THE MODIFICATION OF THE PRACTICES OF THE CARTE DU CIEL PROJECT AT THE END OF THE NINETEENTH CENTURY

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Abstract: Launched in 1887, the Carte du Ciel was an international project aiming at photographing the entirety of the celestial vault. Tasks required for this huge undertaking were divided among eighteen observatories around the globe. Instruments were standardized, and a series of international conferences established operating modes and prescribed norms to be followed everywhere. In each observatory, however, the drive toward uniformity ran into a variety of minor technical and practical problems. In this paper, we examine the strategies mobilized by observers to tinker with stated rules and adapt them to their own experience as astronomers. To underscore the tension between normative prescriptions and individual practices, we consider the *Bulletin du Comité International Permanent de la Carte du Ciel* as an informal forum where various queries raised and arrangements adopted were shared among the scientific community.

Keywords: astronomy, Carte du Ciel project, scientific practices, Ernest Mouchez, David Gill

1 INTRODUCTION

The Carte du Ciel, initiated by Ernest Mouchez of the Paris Observatory and David Gill, Director of the Observatory at the Cape of Good Hope, mobilized eighteen observatories throughout the world. The goal of this international scientific program was to map the sky using photography (Jones, 2000; Lankford, 1984: 29-32). In fact, by employing recent developments in photography, the Carte du Ciel combined at the end of the nineteenth century a traditional astronomical theme (inventory of the sky) and a recent technology (photography). The Carte du Ciel required co-operation on a world scale. It was founded on the definition of common rules for all the astronomers. In this paper I will examine the ways in which the scientific co-operation between the observatories participating in the Carte du Ciel project was organized. I will also detail the role of the international conferences, which were held in Paris in 1887, 1889 and 1891. Then I will study the *Bulletin* of the Permanent International Committee for the execution of the Carte du Ciel, in order to understand how practices coordinated with one another.

2 THE CARTE DU CIEL PROJECT

In 1880 Mouchez, Director of the Paris Observatory, was particularly interested in the development of photography for astronomical applications. In the United States, William C. Bond undertook work on astronomical photography beginning in 1850 (Mouchez, 1887: 12) and in England, Warren De La Rue experimented with astronomical photography starting shortly afterwards (Chinnici, 1999: 3-4). In France Léon Foucault and Hippolyte Fizeau obtained photographs of the Sun of very good quality in 1844 and 1845 (Tobin, 2002: 53-54).

In 1879 Mouchez created a photographic laboratory at the Paris Observatory (Baillaud, 1935: 34), then he encouraged the brothers Paul and Prosper Henry, opticians and astronomers at the Observatory, to build photographic equatorials. They started by developing a camera with an objective of 16 cm. Then, in 1885, the two brothers delivered a camera with an aperture of 33 cm (Mouchez, 1887: 26). Mouchez was filled with enthusiasm by the quality of the instrument. He considered that the photographic objective of the Henry brothers "… goes far beyond all that were made up to now in France or abroad for the photography of the stars." (Mouchez, 1887: 6; my translation).

At the Cape of Good Hope, David Gill, impressed by the images of stars on photographs he took of the Great Comet of 1882, also considered the possible applications of photography to charting the stars. Catalogs of southern stars were few. Mouchez and Gill communicated and conceived an ambitious celestial cartographic project. Their objective was to use photography, not to reproduce the aspect of the stars, but to determine their positions. Mouchez (1887: 8; my translation) spoke about a "… geography of the sky." He wanted the Carte du Ciel to enable the study of "… the distribution of stars in space ... [so that the work of Herschel] will be exceeded and made useless." (Mouchez, 188: 6; my translation). Mouchez insisted on the transformation of the astronomical practice which photography allowed. He noticed that the photographic plate had a greater sensitivity than the human eye: it can distinguish several hundreds of stars where the eye saw only a single compact mass of stars. The astronomer no longer observed directly any more; he simply examined photographic plates with a microscope. Thus it was possible to transport the image of the sky "… into the study." (Mouchez, 1887: 48; my translation). Plates could also be reproduced at will and circulated among interested astronomers. This ambitious project thus rested on the search for a high degree of accuracy and as well on the mechanization of the operations. It should be possible to obtain the positions of more than two million stars in ten or twenty years.

Mouchez wanted to gather together astronomers interested in this project, so he contacted the Royal Astronomical Society in 1885 (Baillaud, 1935: 37) and wrote to Gill and the Directors of the observatories at Harvard, London, Rio and Pulkovo (Chinnici, 1999: 4-5). The reception he received was uniformly favorable. Gill was enthusiastic, and he even proposed to add to the photography of the sky the construction of a catalog of positions of the stars. He also urged Mouchez to organize an international conference.

Table 1: Attendees at the 1887 conference.

Foreign members	
A. Auwers	Prussian Academy of Sciences, Berlin
H.G. Van de Sande Bakhuyzen	Director, Leiden Observatory
F. Beuf	Director, La Plata Observatory
W. Christie	Astronomer Royal, Greenwich Observatory
A.A. Common	Royal Astronomical Society
L. Cruls	Director, Rio de Janeiro Observatory
A. Donner	Director, Helsingfors Observatory
N.C. Dunér	Lund Observatory
J.M Eder	Polytechnic School, Vienna
F. Folie	Director, Brussels Observatory
E. Gautier	Director, Geneva Observatory
D. Gill	Director, Cape of Good Hope Observatory
H. Gyldén	Director, Stockholm Observatory
B. Hasselberg	Pulkovo Observatory
J.C. Kapteyn	Groningen University
E.B. Knobel	Royal Astronomical Society
A. Krueger	Director, Kiel Observatory
O. Lohse	Potsdam Observatory
F.A. Oom	Director, Lisbon Observatory
J.A.C. Oudemans	Director, Utrecht Observatory
C.F. Pechüle	Copenhagen Observatory
J.P. Perry	Director, Stonyhurst College Observatory, Clitheroe, England
C.H.F. Peters	Director, Hamilton College Observatory, Clinton, NY, USA
C. Pujazon	Director, San Fernando Observatory, Cadiz, Spain
I. Roberts	Director, Private Observatory, Maghull (near Liverpool), England
H.C. Russell	Director, Sydney Observatory
E. Schönfeld	Director, Bonn Observatory
A. Steinheil	Instrument Maker, Munich
O. Struve	Director, Pulkovo Observatory
P. Tacchini	Director, Roman College Observatory, Rome
J.F. Tennant	Royal Astronomical Society
T.N. Thiele	Director, Copenhagen Observatory
H.C. Vogel	Director, Potsdam Observatory
E. Weiss	Director, Vienna Observatory
A.G. Winterhalter	U.S. Naval Observatory
French members	
J. Bertrand	Academy of Science
A. Bouquet de la Grye	Academy of Science
A. Cornu	Academy of Science
H. Faye	Academy of Science
H. Fizeau	Academy of Science
J. Janssen	Academy of Science
M. Lœwy	Academy of Science
E. Mouchez	Academy of Science
F. Perrier	Academy of Science
F. Tisserand	Academy of Science
C. Wolf	Academy of Science
B. Baillaud	Director, Toulouse Observatory
G. Rayet	Director, Bordeaux Observatory
C. Trépied	Director, Algiers Observatory
Paul Henry	Paris Observatory
Prosper Henry	Paris Observatory
P. Gautier	Instruments Maker, Paris
G.C. Cloué	Bureau des Longitudes
A. Laussedat	Museum and College of Applied Sciences, Paris
L. Liard	Public Instruction Ministry

3 TESTING INTERNATIONAL SUPPORT: THE PARIS CONFERENCE OF 1887

Mouchez heeded Gill's advice and an inaugural meeting was held in Paris in April 1887, attended by 56 astronomers from 38 nations (see Table 1). After a week of discussions, the objective was laid down:

> … to note the general state of the sky at the current time [and] to obtain data which will make it possible to determine the positions and the magnitudes of all stars up to an order of magnitude … (*Congrès Astrophotographique* …, 1887: 7).

Paris Observatory was at the center of a world-wide network of eighteen observatories. The first question to be settled concerned the distribution of the zones of the sky to be photographed by each observatory. William H. Christie, Director of the Greenwich Observatory, noticed that the observatories of the southern hemisphere (fewer than in the northern hemisphere) would have to take more photographs (*Bulletin* …, 1890: 340).

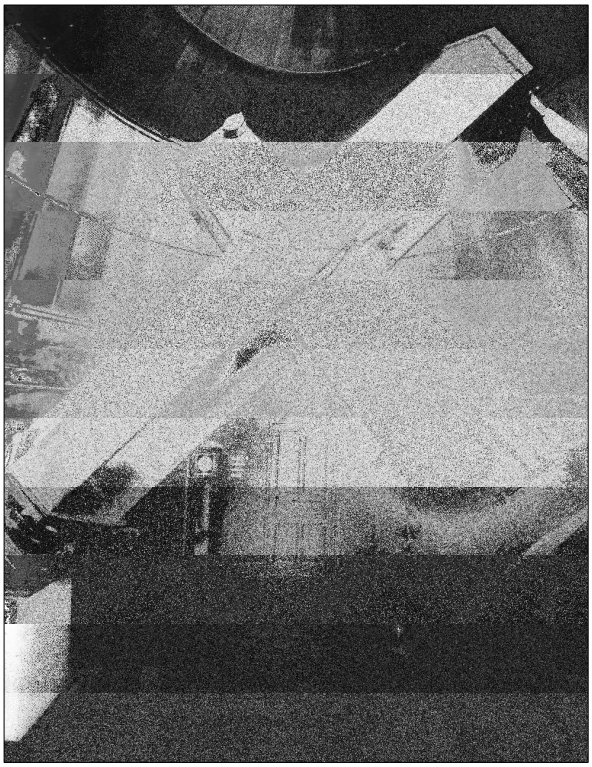


Figure 1: The Carte du Ciel astrograph at the Toulouse Observatory, ca. 1900 (courtesy: Archives of the Observatoire Midi-Pyrénées).

In 1891, the observatories received the co-ordinates of their zones of observation. Almost all the observatories received identical photographic equatorials, each with an objective of 33 centimeters diameter (Figure 1).

The Carte du Ciel required three distinct operations: (1) measuring the positions of stars with a meridian instrument; (2) taking the celestial photographs and processing them; and (3) determining the positions of the stars on the plates. The very large numbers of stars to be measured prevented the astronomers from carrying out all of the calculations themselves, so some observatories created separate computational departments (see Figure 2), while other institutions (e.g. Paris Observatory) entrusted these calculations to female employees.

The Carte du Ciel was one of the first major international scientific projects (Turner, 1918).

3 THE CONFERENCES: THE 'PARLIAMENT' OF THE CARTE DU CIEL

Mouchez (1888; my translation) asked that "… the final and uniform bases of the Carte du Ciel …" be fixed, so the execution, development and measurement of the photographs was thus framed and each operation was detailed. For example, in 1889, a resolution indicated the manner of ordering and of filing the photographic plates (Trépied, 1892: 43). The organizers of the Carte du Ciel required standardization and uniformity of practices. In particular, that applied to the calibration of the observers, and the personal equation of each of them was measured for the evaluation of the sizes of the stars on the plates (Baillaud and Baillaud, 1906: 329).

The first recommendations of the Carte du Ciel project were very prescriptive. This organization of scientific activity falls under a broader movement of transformation of the observatories into scientific factories. The industrial model became dominant at the end of the 19th century, with division of labor, the definition of the tasks and the standardization of the instruments.[1]

However, this regulation of the practices within the framework of the Carte du Ciel quickly caused resistance. For example, the exposure time was fixed at 40 minutes, but some climates did not allow such long exposures (Baillaud, 1929: 644). Some astronomers were skeptical about the possibility of following all of the rules. Thus, Henry Andoyer, from Toulouse in France, preferred to call upon "… the experience of the observer." (Baillaud, 1891; my translation), and estimated that daily experience with the astrograph enabled him to develop a more adequate know-how (see Andoyer, 1891). George Rayet (1901), Director of the Bordeaux Observatory, recognized that certain theoretical considerations for the measurement of star positions were "… impracticable in the reality of things." There was thus a strong tension between a system of standards and local and individual practices.

The organizers of the Carte du Ciel became aware of the danger of maintaining rules that were too strict and limiting. Felix Tisserand, Director of Paris Observatory in 1895, recognized that "… to want to do best, one is sometimes likely to miss the good." (*Bulletin* …, 1895: 344; my translation).

As a result, Mouchez and Gill set up a policy of flexibility, which involved easing the rules and the standards by taking individual situations into account. Two forums for dialogue, distinct but complementary, opened then for the participants of the Carte du Ciel project.

The first related to the international conferences. Initially, they were not supposed to reconsider a decision, but in 1890 Mouchez recognized that it was not a question of a "… absolute law …" (*Bulletin* …, 1892: 290; my translation). It then became possible to revise inapplicable rules or those that were too complex. Thus, at the 1891 meeting several astronomers disputed a resolution which envisaged making only one exposure for each area (Trépied, 1892: 40), proposing three exposures instead, which would make it possible to identify false stars more easily. The discussion was animated, with some astronomers maintaining that the risks of confusion were great in areas of the sky that were very rich in stars. Agreement seemed impossible, and so a technical commission was appointed to examine this issue. It proposed to persevere with single exposures, but to allow certain observatories to take three exposures.

The international Conferences of 1887, 1889 and 1891 defined a whole set of rules to be followed in practice. Thus the Conferences became a 'Parliament' of the Carte du Ciel, in which confrontation and debates were numerous. It was always a matter of seeking a democratic consensus through negotiation.

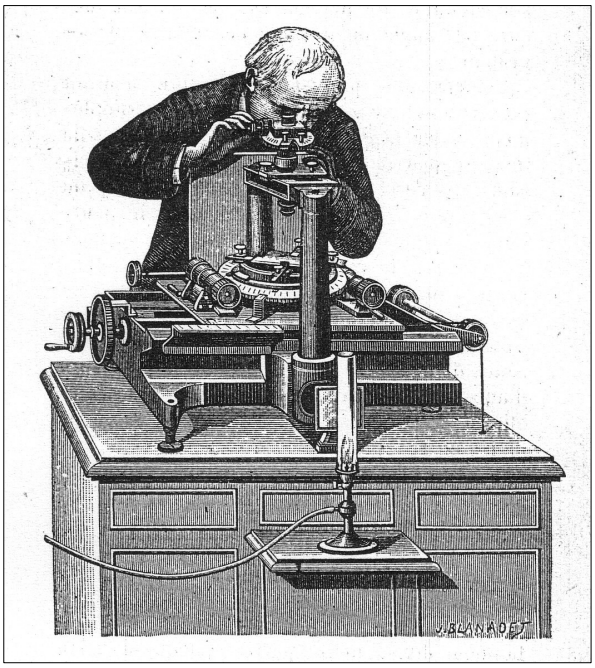


Figure 2: Measuring one of the Carte du Ciel plates (after Mouchez, 1887: 42).

4 THE *BULLETIN*: THE CIRCULATION OF OPINIONS

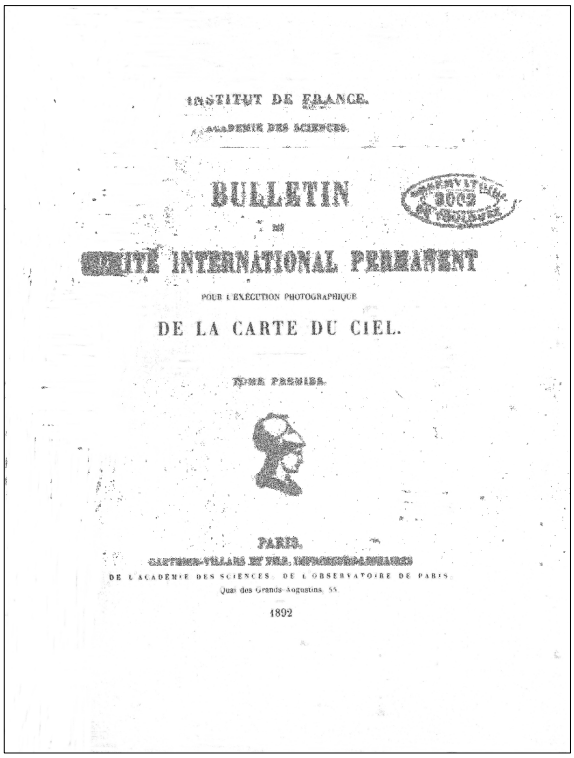
The *Bulletin du Comité International Permanent pour l'Exécution Photographique de la Carte du Ciel* (Figure 3) was the second forum for dialogue, which appeared in 1892 and 1895. I would like to describe in detail the role and contents of the *Bulletin*. The first volume was published in 1892, and in the Introduction Mouchez specified that the *Bulletin* must contain information that will be useful to astronomers taking part in the Carte du Ciel project (*Bulletin* …, 1892: 1).

A section of the *Bulletin* was devoted to correspondence, and contained letters from astronomers concerning their practical suggestions or their difficulties. Mouchez ensured that the discussions were always open and that the objective was to obtain "… a final general opinion …" (*Bulletin* …, 1895: 329; my translation). The *Bulletin* disseminated information and discussion in order to obtain a broad agreement among the astronomers involved in the project. It therefore served to supplement the work of the international Conferences.

We can distinguish three major sets of themes in the first *Bulletins* of the Carte du Ciel project.

The first relates to the examination of the instruments used to take the photographs. The astronomers conducted tests, then published their results in the *Bulletin*. In 1888 Franz Renz (from the Pulkovo Observatory) inspected the photographic plates taken by the Henry brothers and commented on their quality, which met the desired level of precision (*Bulletin* …, 1892: 275).

In the same manner, the astronomers described their first experiments with the camera. In 1891, Charles Trépied, Director of the Algiers Observatory, assured his readers that after four months of use and tests, the photographic equatorial functioned well (*Bulletin* …, 1892: 372).


INSTITUT DE FRANCE.

ACADÉMIE DES SCIENCES.

BULLETIN

DU

COMITÉ INTERNATIONAL PERMANENT

POUR L'EXÉCUTION PHOTOGRAPHIQUE

DE LA CARTE DU CIEL.

TOME PREMIER.

PARIS.

GAUTHIER-VILLARS ET FILS, IMPRIMEURS-LIBRAIRES

DE L'ACADÉMIE DES SCIENCES, DE L'OBSERVATOIRE DE PARIS

Quai des Grands-Augustins, 55.

1892

Figure 3: Cover of the first volume of the *Bulletin du Comité international permanent pour l'Exécution Photographique de la Carte du Ciel* (1892).

Among the technical studies, the comparisons between different materials played an important part. For example, the astronomers devoted considerable time to the collective evaluation of the screens intended for the calibration of the image sizes. The various points of view and technical tests made it possible to obtain a consensus and to better determine the limits of the instruments.

Exchanges with the manufacturers were also important if the astronomers were to understand the operation of the equipment and avoid possible practical difficulties. The *Bulletin* allowed these discussions between scientists and manufacturers. Hermann Vogel, Director of the Potsdam Astrophysical Observatory, wrote a letter in July 1890 about the grid which made it possible to locate the position of stars. He noticed that too much pressure between the photographic plates and the grid led to notable misreadings (*Bulletin* …, 1892: 366). The manufacturer, Paul Gautier, who was responsible for constructing the grids, provided an answer for Vogel. He explained that the frame took into account characteristics of the plates and avoided placing too much tension on the glass (*Bulletin* …, 1892: 367).

The second topic which one finds in the *Bulletin* relates to the division of the experiments. The astronomers described their difficulties, the problems which they encountered and solutions that they implemented. In 1895, the *Bulletin* published several remarks in connection with the grid, which contained a very fragile layer of silver. Layers became uneven at different places, which could create false stars on the photographic plates. The *Bulletin* (1895: 123) outlined the method adopted by the majority of the astronomers to solve this: the regular use of a brush to remove dust from the grid in order not to produce false stars. These exchanges made it possible to understand the limits of the rules fixed at the beginning of the project.

From the same point of view, the *Bulletin* revealed the differences in methods between countries. Thus, there was a difference of opinion between the French and Finnish astronomers concerning the scale of the sizes of the star images. The French used a single multiplying coefficient between the exposure time and the size of stars (*Bulletin* …, 1895: 107), while the Finns gradually varied this coefficient according to the size of stars (*Bulletin* …, 1895: 109). Each side presented their arguments by publishing long reports in the *Bulletin*. The French astronomers considered that the method used by the Finns was not very reliable (*Bulletin* …, 1895: 113).

The *Bulletin* allowed a greater circulation of the experiments and the methods used in connection with the Carte du Ciel project. It forced astronomers to detail their practices and to compare them with those of their colleagues. It also started an international discussion on the methods of observing and of using photography in astronomy.

The third important topic that one finds in the *Bulletin* is the complaints that the rules were too constraining. Certain astronomers clearly acknowledged that they did not follow the resolutions of the Conferences. For example, Robert Ellery, Director of the Melbourne Observatory, explained that he did not take photographs each evening, as requested (*Bulletin* …, 1895: 449), since the Melbourne sky was too variable to allow this.

The resolutions voted in the Conferences were sometimes called into question. Thus, Gill recognized in 1892 that it is perhaps not necessary to require fixed exposure times. Instead it was left to the observer, whose experience would enable him to be the best judge of the appropriate exposure time (according to the transparency of the atmosphere, the stability of the images and the sensitivity of the plates) (*Bulletin* …, 1895: 119). Thus, the know-how of the astronomers sometimes replaced the initial rules. In the long term, this desired uniformity threatened the success of the Carte du Ciel project: too many constraints and requirements could paralyze proceedings.

The Carte du Ciel organizers accepted that each observatory had its own measuring machine for the plates. Certain astronomers used machines allowing for faster but less precise measurements. The important thing for the organizers was that the various techniques were properly documented.

The *Bulletin du Comité International Permanent pour l'Exécution Photographique de la Carte du Ciel* was an effective means of adjusting practices and coordinating activities. In particular, through the *Bulletin* it was possible to correct the system when it was too rigid. The circulation of the memoirs and letters transformed the scientific practices in the participating observatories. Technical remarks, different scientific traditions adopted by the participating countries and concrete solutions all appeared in the *Bulletin*, which was used to negotiate and build collective rules of work.

5 CONCLUSION

The beginnings of the Carte du Ciel project were marked by an important transformation in the organization of scientific activity. The organizers of the project initially imposed a very strict system of rules to coordinate work of all the participating observatories. This step is characteristic of the regimes of knowledge which were set up in the West in the second half of the nineteenth century. The observatories were simply scientific factories. The industrial model was characterized by the division of labor and the standardization of instruments. With regard to the Carte du Ciel project, this scientific policy quickly became ineffective due to differences between observers and local observing conditions. So the organizers of the Carte du Ciel project modified the rules of the work. Two forums of dialog developed: the international conferences and the *Bulletin du Comité International Permanent pour l'Exécution Photographique de la Carte du Ciel*. Collectively, they made it possible to find a balance between universal standards and local demands and practices. The adjustment of the practices was initially a collective work of negotiation.

In conclusion, I want to propose an explanation for the radical transformation of the diffusion process of the rules and conventions within the framework of the Carte du Ciel project. Several studies in the history of science (e.g. Biagilo, 1993; Détienne, 1965; Vernant, 1968; and Shapin and Schaffer, 1986) underline the powerful bond which links a mode of political organization at a precise moment and conventions which govern the scientific community and its practices at that time.

In the case of the Carte du Ciel project, the astronomers were careful to underline the major role to be played by France. In 1887, Otto Struve, the Director of Pulkovo Observatory, recognized that the initiative of the project was entirely that of France (Baillaud, 1929: 644). For their part, the French authorities—as stated by Louis Liard (1886), Director of Higher Education in the Ministry of Education—demanded that France play a major part in this important scientific project. One can link this insistence on establishing the prominent role to be played by France with the emergence of a new political regime which was set up with the Third Republic. The French Parliament was at the center of the democratic system (Berstein and Milza, 1996: 395), and at the same time the laws on freedom of the press allowed the expression and the circulation of opinions and ideas (Terrou, 1972).

The Carte du Ciel project was marked by the French republican and liberal political regime, which emerged after 1870. For the political world, just as for the scientific world, research by consensus emerged by the installation of democratic rules and the possibility of free expression. Benjamin Baillaud, Director of the Toulouse Observatory from 1878 to 1907, recognized the existence of a powerful link between the organization of the Carte du Ciel project and the new political orientation that emerged after the destruction of the Second Republic by the Prussians in 1870. He ensured, in 1899, that the "… decentralization of scientific work and resources … [wished by the republican government, was done] for the benefit of Science and Homeland." (Baillaud, 1899: 1).

However, the originality of the Carte du Ciel project lies less in the convergence of the political and scientific forms of organization than in the will of the French scientific community to diffuse, on a world scale, the new principles of government, set up by the republican system. The Carte du Ciel project constitutes from this point of view, for France, a first experiment in the propagation of a model of research organization.

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7 NOTES

1. In this context, Osterbrock et al. (1988) refer to W.W. Campbell as "The Creative Scientist Who Became a Factory Manager" in a chapter of their book on the history of the Lick Observatory.

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