

THE "CARTE DU CIEL" INSTRUMENT OF SAN FERNANDO: A CENTURY OF ACTIVITY.

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ABSTRACT. The installation of the "Carte du Ciel" instrument was of great transcendancy for the history of the Instituto y Observatorio de Marina. After briefly outlining the main difficulties for the development of the Observatory by that time, the personality of Captain Pujazón, responsible of the improvement of his institute and organizer of the work of the astrograph at San Fernando, is commented. We describe the spanish participation in the "Carte du Ciel" campaign and the subsequent use of the instrument in different international programs until the present days. The profitableness of the astrograph in continuing to support some aspects of the modern astrometrical research, is concluded.

1. INTRODUCTION.

The "Carte du Ciel" enterprise was for the "Instituto y Observatorio de Marina" the historical connection between its foundational objectives and the astronomical science to come.

Founded in 1754 "to help navigation by astronomical means", the Observatory had self-defined by that time, after more than a century of services to the navy, its own character and configuration. In this configuration, its response to the needs and urgencies of the navy played an important part, not only in astronomical affairs, but in connection with collateral sciences and techniques.

In the beginning the primary need to cover was the introduction of astronomical knowledge and practices for their immediate use in navigation. This brought about an early development of systematic positional astronomy, the study of astronomical time, and the observation of any kind of natural phenomenon that could be used for longitude determination. By the end of the 18th century, a royal order commanded also that the Observatory take charge of the production of Nautical Ephemeris.

Surveying was also an important task for naval officers who prepared expeditions, received training and checked their instruments at the Observatory. Through this last practice, the establishment became invol-

ved in the custody and repairs of instruments, and, from then on, in the provision and maintenance of marine chronometers.

Officers coming from the High Studies courses imparted at the Observatory began to gain a reputation in and out of the navy and were entrusted with technical or scientific missions. The Observatory itself began to be considered as consultant body, called to solve scientific questions of naval or geographical interest in the fields of the astronomy and in those of the earth sciences.

The growing of such heterogeneous tasks, aside from the main research lines of the Observatory, impinged upon the development of its astronomical objectives. Systematic astronomy, demanding great devotion and continuity, proved to be incompatible with other activity. Even the production of ephemeris, originally conceived as an auxiliary work, distracted the directors from their main responsibilities in observations. Furthermore, the Efemérides turned out to be, during the periods of scarcity of qualified personnel, the main objective for the improvement and research of the Observatory, chiefly in those aspects connected with navigation.

During the second half of the 19th century things moved slowly towards a stabilization. The method of lunar distances, used to determine the position at sea, which had originally stimulated astronomical research, was gradually replaced by newer, more practical methods; sextants and chronometers, even though in evolution, permitted to predict many years in advance, that future needs in nautical ephemeris would hardly surpass the one arc-minute level.

Under such conditions astronomical research in the navy began to lose its primary importance. The pressure of more simple everyday needs tended to convert the Observatory into a kind of naval institute, able to compute ephemeris, to observe and maintain astronomical time for the ships and to keep their chronometers in order.

But, fortunately, at the same time, the Observatory, in contact with practical science, continued to be considered as the traditional school for the improvement of the knowledge of small groups of selected navy officers, as well as the natural adviser and organizer of every global scientific activity.

It was during this crucial moment in the life of our institute that Lieutenant Cecilio Pujazón took command of the Observatorio de Marina.

2. THE LIFE OF CECILIO PUJAZÓN

The scientific trajectory of Cecilio Pujazón (1833-1891), one of our prominent naval astronomers, started with his admission in 1846, in the newly founded "Colegio Naval Militar" at San Fernando.

After some years of theoretical studies, he fulfilled his naval training on-board ships assigned to the Apostadero de la Habana (1849-1852), initiating with this his everlasting ties with Cuba. He would return to the island as a navy officer (1853-1857), then as an expert in hydrography (1861-1869) and finally as an astronomer, to observe the solar eclipse of 1878 and the transit of Venus of 1882. He also was

married in Cuba in 1864.

Pujazón had occasion to improve the basic knowledges of his profession by carrying out a three year "High Studies" course in the Observatory at San Fernando. The subjects in these studies were mathematics, mechanics and languages, all followed by practical training in each of the astronomical observations made at the center, plus participation, in his case, in the observation of a solar eclipse in 1860 and in astronomical positioning on land. As many other naval astronomers, Pujazón had to discontinue his studies during a short time, in 1859, to attend to military duties during our first Africa war.

In his hydrographical missions, both in Spain and Cuba, besides the mapping of the coasts, he devoted special attention to establishing nets of geographical positions observed with an astronomic theodolite. He obtained the latitudes following the Bessel method by observing at the prime vertical. To derive longitude differences he frequently used, after 1860, the method of clock comparisons by telegraphic signals and, in some cases, that of the transportation of chronometers. His most remarkable experience consisted in the determination (jointly with Prof. Harkness, from the U.S. Naval Observatory; during his command of the "Comisión Hidrográfica de las Antillas" in 1868) of the longitude difference between the Washington Observatory and the lighthouse of El Morro at La Havana, using the telegraphic method.

Lieutenant Pujazón was appointed Director of the Observatory of San Fernando in 1869. He devoted his efforts, from the beginning of his office, to improve the organization and activities of the establishment in all aspects. He discarded astrophysics from the main objectives of the Observatory, and/or hastened the provision and the installation of modern astronomical instruments such as a Bruner and Salleron reflector of moderate aperture and a large refractor ($O= 28\text{cm}$, $f=5\text{m}$) in equatorial mounting from Bruner. He re-started the activity of the Troughton and Sims Meridian Transit Circle, existing at the Observatory since 1859, and organized new series of systematic observations from 1876 on. He completed the astronomic equipment with chronographs and other necessary elements.

In 1877 he started a service to distribute astronomical time to the ships in the vicinity, using the falling sphere method; made substantial improvements in the theories and contents of the Spanish Efemérides, and personally organized the cataloguing of the library.

He attended, in 1874, the Conference of Maritime Meteorology and was commissioned by the government to the 2nd International Congress of Meteorology in 1879. His reports and proposals on this matter soon gave rise to the creation in Spain of a Coastal Meteorological Service, whose organization and further responsibilities fell to his own observatory until 1887. It was at that very moment that the International Conference, to deal with the possibilities of obtaining, by world-wide co-operation, an atlas of the entire sky, was convoked by Mouchez.

Pujazón, being aware of the transcendence of the idea of his colleague in Paris, made use of his personal prestige and enthusiasm to convince his superiors, both in the Navy and in the government, of the benefits that the engagement in such an ambitious project would

bring to the Spanish science and to the Observatory.

The immediate results of his actions were the definition of a very important scientific mission for his observatory, the acquisition of a modern instrument promising durable activity, the recruitment of part of the necessary personnel and the re-organization of the Observatory around well defined objectives. The most important result, in the long run, would be the opening of his establishment to the big enterprises and international services of the future.

3. THE ZONE OF SAN FERNANDO.

It is easy to verify, especially through our French colleagues, that the professional lives of Admiral Mouchez and Captain Pujazón, are full of similarities. This coincidence would certainly facilitate the mutual understanding of both directors around the international proposal of the admiral.

Pujazón, being convinced of the importance of the enterprise to be undertaken, worked hard on both international and national aspects, contributing to its success: 1) As a member of the Permanent Committee for the *Carte du Ciel*, in the service of its global organization and 2) as Director of the Observatory, making ready the works for the completion of the Zone assigned to San Fernando (-3° through -9°).

In 1890, only three years after the Astrographic International Congress (IV-1887) in which the mapping of the sky was first discussed, the Observatory of San Fernando carried out its final tests of the instrument, as foreseen by the Permanent Committee. This efficiency in the achievement, starting from zero, of an original concept may seem surprising, even to the eyes of today's better organized and communicated astronomer.

Pujazón died in San Fernando, when returning from the 3rd meeting of the Permanent Committee in April of 1891, with all the arrangements for his observatory's work in progress. The last years of activity had been very exhausting ones. Intensely devoted to the project, he had personally participated in every management; designed and surveyed the building of the observation's pavillon and installed and adjusted the instrument. Having established the first instructions for the works, he left after him a small team of trained collaborators.

His successor, Captain Viniegra, assumed with the same spirit the commitments of the Observatory and immediately began, in 1891, the observations for the Catalogue series which he completed during 1894. In 1903, Tomás de Azcárate took over directorship. His first job was to make an exhaustive revision of every observed plate, after which he took the decision to re-do an important part of the work. He repeated about 40% of the Catalogue collection and re-observed all the plates previously taken for the Chart. The definitive work was achieved in 1917 for the Catalogue and in 1923 for the Chart plates. At the same time he organized measurements, completed theories and gave instructions for reductions. The publication of the Catalogue results was made between 1921 and 1925, and the atlas of the Zone some years later.

The Astrographic Catalogue of San Fernando is contained in eight volumes, one for each degree of declination, plus tables and explanations. It gives, for each of its 1260 plates, besides general data, the standard coordinates of the measured stars, and plate constants referred to the Katalog der Astronomischen Gesellschaft (C.A.G.). In plates where the selection of sufficient C.A.G. reference stars were not possible, complementary stars were taken from the Bonner Durchmusterung (B.D.) catalogue. These were previously referred to in the C.A.G. system from measurements made in contiguous plates.

Magnitudes were derived from the image diameters on the plates using Christie's formula taking as standard of magnitudes the B.D. catalogue.

The Catalogue of the Zone is now out of print. Some originals of the engraved copper negatives of the charts are missing, but printed collections are still available. The archives of the plates remain in good condition.

4. FURTHER WORK

In the first decade of the 19th century, the instrument began to be used, alternatively with the mapping of the Zone, in various observations of comets, planets, asteroids, eclipses ...etc. During the 1900-1901 opposition of Eros, in which an approach to the Earth of 0.27 astronomical unit was expected, the astrograph was used to obtain precise positions to derive an accurate parallax. Observations were made in two separate campaigns in which 287 plates were exposed.

In 1932 the moment seemed to have arrived to start a second campaign of observations for position and proper motion determinations, but work on this occasion would not be as expeditious as on the first one, mainly because of the Spanish Civil War and subsequent post-war difficulties. During this interval of low productivity (July 1936-January 1946), only 128 plates were obtained.

At the end of 1945, Lieutenant Commander V. Planelles was assigned to the Section of Astronomy of the Observatory. Under his care the section began to renew progressively its instrumentation for positional astronomy (Meridian Circle Grubb-Parsons, quartz clocks, Danjon astrolabe ...) meanwhile he centered the observational activity of the section on the Gautier astrograph. He started a regular program of observations of minor planets, whose positions he determined by the method of dependences. Asteroids of particular interest such as 51 Nemausa, were at that time the object of intensive campaigns.

Planelles re-organized the proper motions activity by increasing the rate of the observations of the second epoch plates and initiating, at the same time, measurements and reductions by the film-to-film method. This work, from which some results were published, never came to an end, because of the engagement of the Observatory in the "International Geophysical Year" campaign (I.G.Y) which required a new distribution of activities. The continuous degradation of the seeing in San Fernando skies will, unfortunately, never permit any new mapping of the Zone.

On the occasion of the I.G.Y, the instrument was equipped, following a proposal of W. Markowitz from the U.S.N.O., with one of his dual-rate moon cameras, designed to position the moon with reference to the neighbouring stars, and an important number of plates were sent, each lunation, to the measuring center at the Paris Observatory, between January 1958 and November 1959.

By that time, a large part of the participants in the Carte du Ciel project had declared their works concluded, and new suggestions for the international use of the instrument began to circulate. Planelles chose the proposal of Prof. Deutsch, from Pulkovo Observatory, aimed at the determination of proper motions with reference to extragalactic nebulae, as his next objective, starting the observations immediately. During Planelles activity, the yield of the instrument amounted to 2444 plates.

At the end of 1969, with L. Quijano as the head of the Astronomy Section, the equatorial was overhauled and its dome repaired. New devices were installed to ease the observations and to improve its motions. He continued the Pulkovo program in the -5° to -25° Zone comprising 48 plate centers, in which 230 nebulae were found. This work consisted of 144 observations, three for each of the assigned areas. The measurements were made successively in the plate-measuring machines of Bordeaux and Madrid by López Palacios and his team that published their results in 1969 and 1971. These consisted in the description and evaluation of the nebulae, and in one catalogue with the coordinates of the objects and those of the reference stars, plus a certain number of control stars above magnitude 12.

Today, the instrument, equipped with a modern "Ascorecord" measuring machine, is working at a rhythm compatible with other astronomical activities of the Observatory. Its most recent objectives are the observation of selected asteroids for the Institute of Theoretical Astronomy in Leningrad and the positioning of other minor planets within the "Hipparcos" observing list. The number of plates in its archives is ever increasing: 1501 plates were added during Quijano's activity, making a total of 9376 plates at the writing this paper.

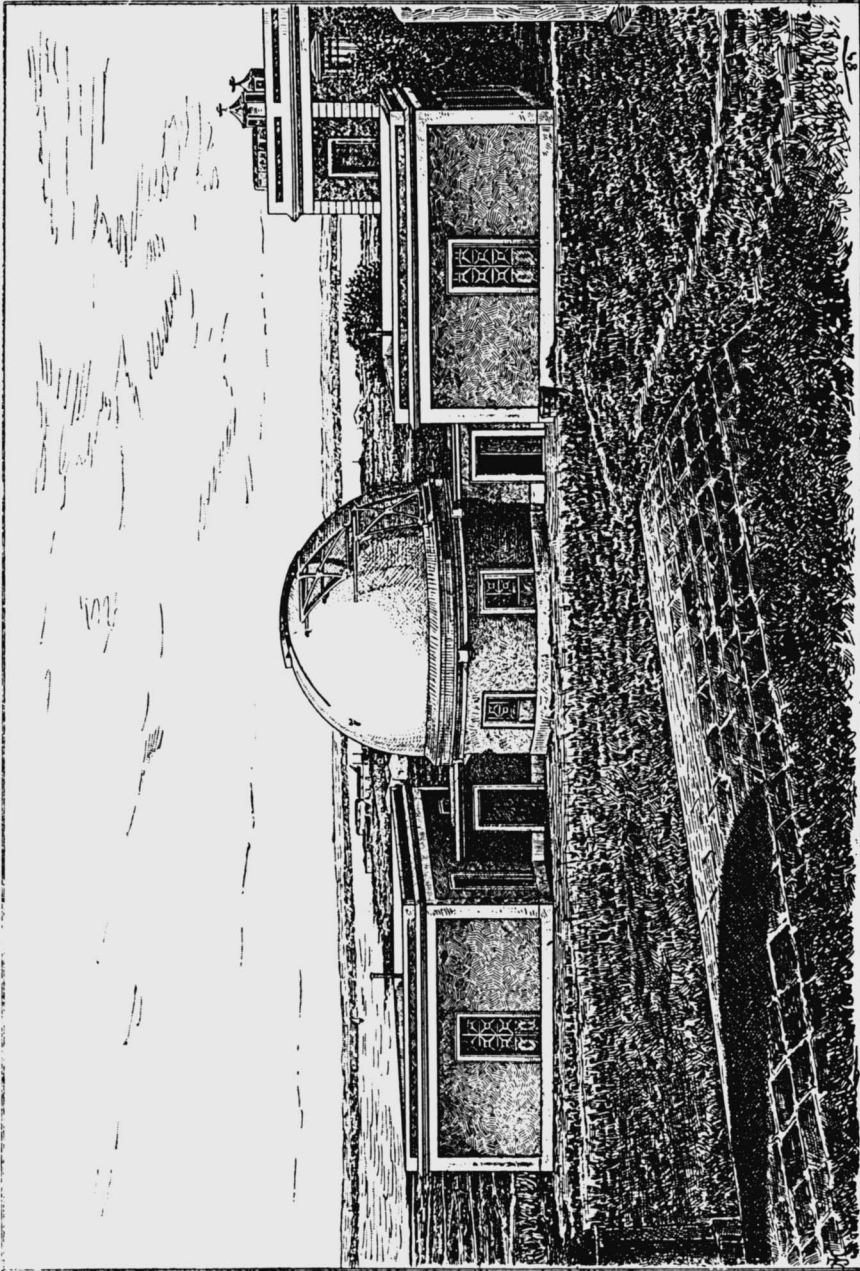
The Henry-Gautier astrograph of San Fernando, which has been quietly contemplating the speedy progress in the equipment of the more modern instruments in its vicinity, continues contributing, month after month, to important tasks in today's astronomy.

5. ACKNOWLEDGEMENTS

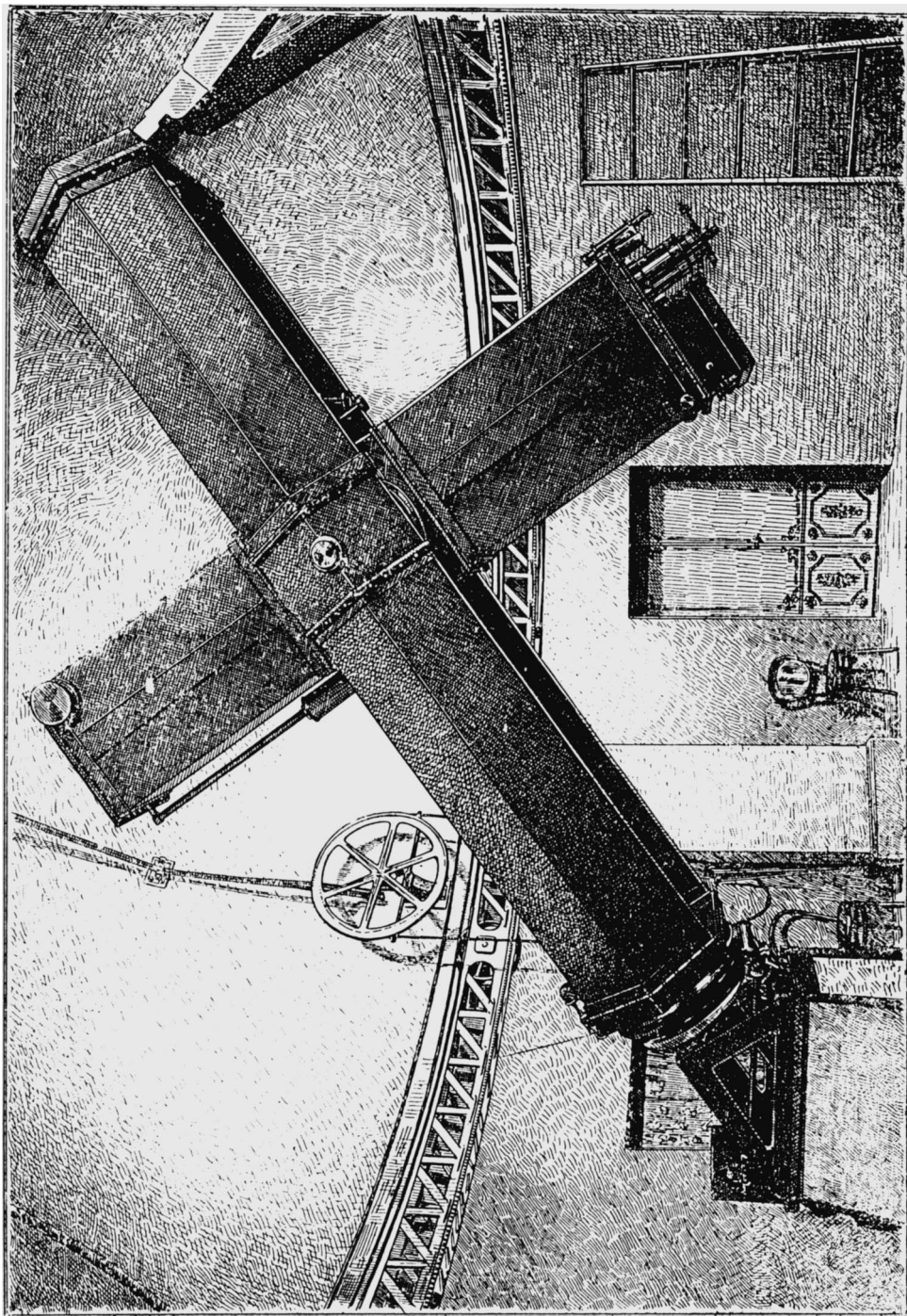
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Captain Cecilio Pujazón, Spanish member of the Permanent Committee for the "Carte du Ciel".



The "Carte du Ciel" pavillon of San Fernando



The Henry-Gautier astrograph of the Observatorio de Marina in 1890

Discussion:

JASCHEK The Madrid Observatory was never interested in the Carte du Ciel?

ORTE As an expensive national enterprise, the Carte du Ciel collaboration should not be committed to more than one Spanish Observatory. It was previously agreed that San Fernando would take charge of the work.