EVOLUTION OF THE FOUCAULT-SECRETAN REFLECTING TELESCOPE

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Extract – Section 10
Foucault-style telescopes by other makers

Note:
A Corrigendum (concerning typographical errors) & Addendum (concerning a newly-discovered 10-cm telescope in a metal tube) is scheduled to appear in volume 19 issue 3

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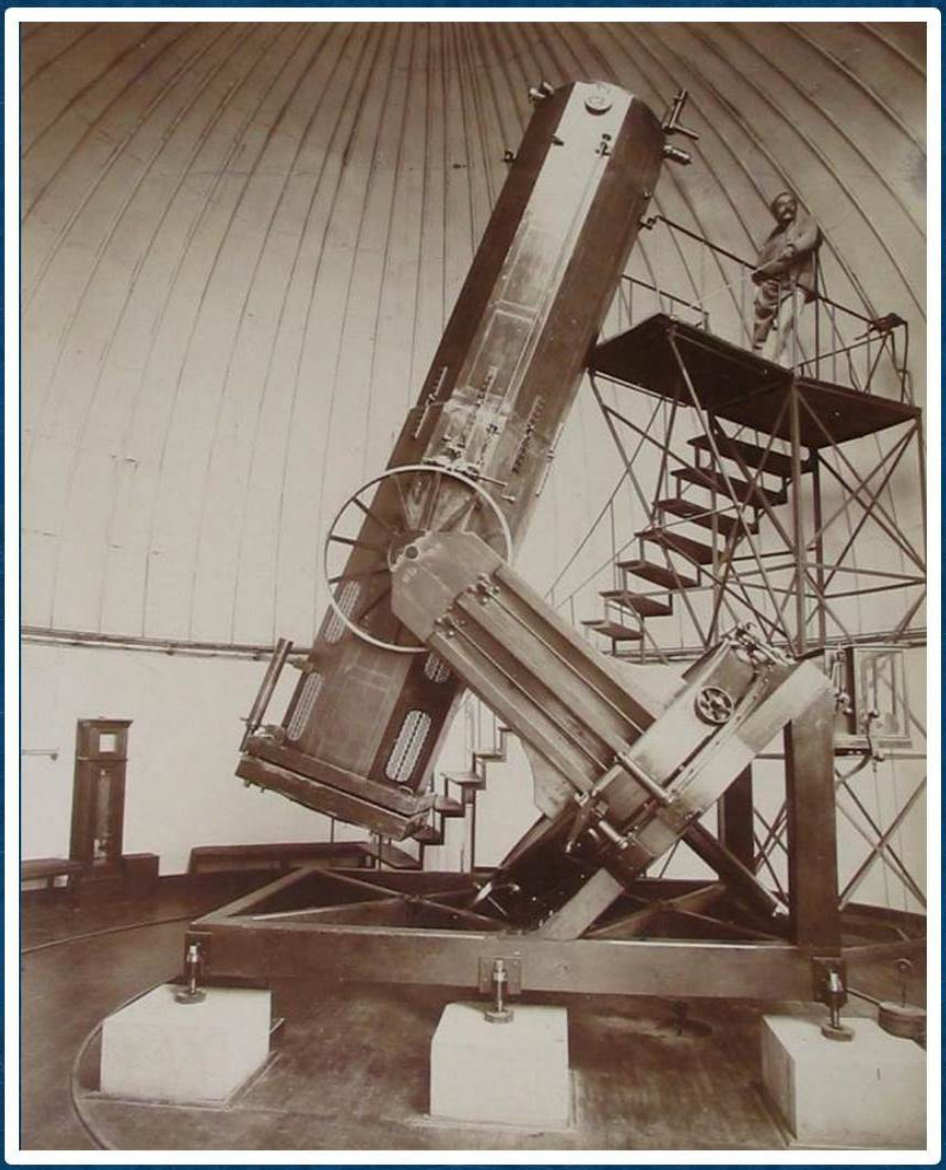

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COVER IMAGE

The 80-cm telescope delivered to Toulouse Observatory in 1875. Although construction began under Léon Foucault and Marc Secretan, neither lived to see the result. From about 1855, the pair had begun to devise and perfect silvered-glass mirrors for telescopes. This freed astronomy of an archaic speculum technology and paved the way for reflecting telescopes of 5-m and more in diameter. Read William Tobin's fascinating paper, beginning on page 106.

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EVOLUTION OF THE FOUCAULT-SECRETAN REFLECTING TELESCOPE

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Abstract: Léon Foucault developed the silvered-glass reflecting telescope in collaboration with the instrument maker Marc Secretan. Almost immediately, they began selling 4- and 8-(French)-inch Newtonian telescopes in wooden tubes to amateurs. Several 4-inch examples have survived. As Foucault attempted to make larger diameters he moved from spherical to paraboloidal mirrors and developed tests to determine the errors of the surfaces he was polishing, of which the knife-edge test is the most informative and sensitive. The errors were then corrected with *retouches locales*, i.e. local repolishing. He also introduced the concept of *pouvoir optique*, or optical power, to characterize the performance of his mirrors. He made several professional reflecting telescopes, culminating in the 80-cm instrument now at the Marseilles Observatory. A number of his instruments are illustrated in physics textbooks of the time. Foucault predominantly adopted an *f*/6 focal ratio with a prism secondary close to the prime focus and a microscope-like eyepiece assembly to bring the image to the observer. In 1865, with Marc's son Auguste, Foucault announced a metal-mounted 10-cm alt-az amateur instrument, which soon became available in larger sizes and with equatorial mounts. Several examples survive. In 1866 the head of the Secretan workshop, Wilhelm Eichens, split from the firm. Marc died in 1867, followed by Foucault in 1868. Foucault's pupil Adolphe Martin published some of Foucault's mirror- and lens-making secrets. Martin worked with both Eichens and, episodically, the Secretan firm; but though able to figure small mirrors he proved incapable of finishing 80- and 120-cm ones begun under Foucault destined for the Toulouse and Paris Observatories. Auguste Secretan associated with Paul and Prosper Henry for mirror figuring. The Secretan offering of silvered-glass telescopes reached its apogee in 1874 with advertised diameters from 10 to 80 cm. Auguste died that year and the firm was taken over by his cousin Georges Secretan. Production of silvered-glass reflectors and other scientific instruments languished, and focal ratios slowed. Production appears to have revived after R. Mailhat became Director of the company's workshops and then founded his own firm. In 1903 the Secretan Company offered a simplified 125-mm reflector designed specially for members of the Société Astronomique de France, perhaps promoted by Georges' son Paul. Foucault-style reflecting telescopes were offered by other makers too, including Jules Duboscq, Édouard Lutz and Albert Bardou. Following Georges' death in 1906 the Company was operated by Paul before being sold to Charles Épry in 1906 who associated with Gustave Jacquelin in 1913. Only 125- to 200-mm amateur reflectors were offered in their 1924 and 1942 catalogues. Non-specific advertisements for reflectors continued beyond amalgamation with the Morin Company in 1963, but disappeared after a subsequent merger with the Société de Recherches et de Perfectionnements Industriels c.1967.

Keywords: Reflecting telescope, silvered glass, Léon Foucault, Secretan firm, Wilhelm Eichens, Adolph Martin, Henry brothers.

1 INTRODUCTION

A key step in the development of the modern telescope was the invention in 1856–1859 of the silvered-glass reflector by Léon Foucault (1819–1868; Figure 1). Reflective elements are of course exempt from chromatic aberration, and compared to speculum metal, glass permitted cheaper, lighter, stiffer and less-brittle mirrors with a smaller coefficient of thermal expansion. When darkened by sulphide, the silver surface could be renewed without the refiguring required by tarnished metal mirrors. Crucially, Foucault's method of *retouches locales,* or *local corrections* (whereby errors of form were discerned by optical testing and then corrected with local repolishing) opened the way to large apertures with fast focal ratios. (Here, and throughout this paper, all translations from the French are mine unless stated otherwise.) The superior reflectivity of silvered glass promoted the subsequent development of Cassegrain and other systems with two reflections. It is no wonder that Foucault's invention has been described by Ray Wilson, the renowned optical designer, as "... *one of the most important advances in the history of the reflecting telescope.*" (Wilson, 1996: 414; his italics).

I have outlined Foucault's development of the silvered-glass reflector elsewhere (Tobin, 1987 and especially 2003). Here I establish the advances and their chronology in greater detail, taking account of newly-discovered manuscript and printed material (e.g. Foucault, 1852–1865; 1857a; 1863; Sebert, 1867–1868).

Foucault's telescope experiments were conducted in association with the Swiss-born mathematician Marc Secretan (1804–1867; Figure 1), who was the owner of a large firm making precision instruments as well as being the Paris Observatory's official optician. Secretan was from Lausanne. He had trained as an advocate, but had taught mathematics at the Collège (now Université) de Lausanne before moving to Paris where he had partnered with the optician N.M.P. Lerebours (1807–1873). When the partnership

why no prices were quoted.

In March 1963 the Secretan company amalgamated with the Henri Morin company, founded in the 1880s, and known particularly for surveying and drawing equipment (Legros and Boyelle-Morin, 1963). The new entity traded as Etablissements H. Morin-Secretan. The last advertisements that I have found for Morin-Secretan appear in *L'Astronomie* in the 1960s and include "Télescopes" (Figure 88). Around 1967 the firm merged with the Société de Recherches et de Perfectionnements Industriels (SRPI), a company that had been formed in 1918. This probably heralded the end of almost two centuries of telescope making by the firm, whether of reflectors or refractors, because I have found no Morin-Secretan-SRPI advertisements.[59] The joint company took out patents until at least 1981, and subsequently disappeared.

10 FOUCAULT-STYLE TELESCOPES BY OTHER MAKERS

The superiority of Foucault's reflectors was quickly apparent. In his 1860–1861 catalogue of available instruments, the optician Arthur Chevalier (1830–1872) noted that metal-mirrored reflectors were "... completely abandoned ..." and that with silvered glass, Foucault had "... recently developed practical means for producing reflecting telescopes ..." (Chevalier, 1860–1861: 67)

As we have seen, commercial restructuring meant that other companies also offered Foucault reflectors. Eichens left the Secretan firm in 1866 and produced the mechanical parts for many telescopes. Eichens' successor, Gautier, remounted the Toulouse 80-cm reflector in metal beginning in 1886 (for an engineering drawing and photograph, see Bach et al., 2002: 191–193). In the same year Gautier contracted to build a similar equatorial telescope for the newly-founded La Plata Observatory, with a mirror figured by the Henry brothers (Hussey, 1914). Gautier and the Henrys also built the 1-metre *grand télescope* for the Observatoire de Meudon, installed in 1891. Its revolutionary *f*/3 mirror was designed for photography and diffuse-object spectroscopy (Janssen, 1896). We have seen that Martin provided silvered-glass mirrors for eclipse and Transit of Venus expeditions. A 38-cm diameter mirror (focal length = 1.42 m, ~*f*/4) was polished by a Monsieur Cache, a worker in the Bardou company of optical fabricants, for observations of the 1871 solar eclipse (Flammarion, 1874b: 248; Janssen, 1873: 107).

The above were all professional instruments. But the Secretans rapidly lost the monopoly for the supply of amateur silvered-glass telescopes as well. I have found 'Télescopes de Foucault'

Figure 87: Martin's mirror from the Paris 120-cm telescope was refigured in the 1930s by the optician André Couder and installed in 1942 at the Observatoire de Haute-Provence. The mirror was chipped soon afterwards and is now on display at the Observatory. The damage has been hidden by the large bevel (courtesy: www.obs-hp.fr).

offered in the catalogues of several other Parisian instrument makers (Tables 3 and 4). It must be noted that re-badging and on-selling was common in the Parisian scientific-instrument trade (Brenni, 1989; 2002), so it is very possible that some of the equipment sold by others may have still been made by Secretan or successors. Further, some components, such as iron castings, may well have been outsourced, and thus were perhaps available to several instrument makers. (There are no items obviously intended for casting in the 1867 inventory of Secretan's business (Sebert, 1867–1868).) The aforementioned Arthur Chevalier offered what is clearly the Foucault-Secretan 4-*pouce* télescope for on-sale in an 1860 catalogue (Tables 3 and 4), and we have seen that Duboscq offered small reflectors as early as 1864.

In his later catalogues Duboscq continued to offer "*Télescopes*, L. Foucault system", but with less details specified (Table 4). Foucault and Martin apparatus for the "... inspection and veri-

Figure 88: One of the last Morin-Secretan advertisements briefly mentioning reflecting telescopes ("Télescopes") (after: Etablissements H. Morin-Secretan, 1964; courtesy: Google Books

INSTRUMENTS D'OPTIQUE A L'USAGE DES SCIENCES

CINQ MÉDAILLES DE 1re CLASSE

GRANDE MÉDAILLE D'OR A L'EXPOSITION DE MOSCOU 1872

E. LUTZ

FOURNISSEUR DES ÉCOLES FRANÇAISES ET ÉTRANGÈRES

Rue des Noyers, 49 (boulevard Saint-Germain).

SPECTROMÈTRES
DE
MM. BUNSEN et KIRCHHOFF

Spectroscopes de poche. 25 fr.

LUNETTES DE ROCHON
POUR MESURER LES DISTANCES

NOUVEAU MODÈLE DE
DIABÉTOMÈTRE DE ROBIQUET
ET DE
SACCHARIMÈTRE

PRISMES DE NICOL
DEPUIS 3 FRANCS LA PIÈCE

TÉLESCOPES DE FOUCAULT
Nouveau modèle.

MIROIR : DIAMÈTRE, 10 CENTIMÈTRES 1/2
CORPS : 85 CENTIMÈTRES
AVEC CHERCHEUR
1 OCULAIRE TERRESTRE
2 OCULAIRES ASTRONOMIQUES
ACCOMPAGNÉS D'UNE
BONNETTE EN VERRE NOIR,

LES OCULAIRES
PEUVENT SERVIR POUR MICROSCOPES

MONSIEUR,

J'ai l'honneur de vous présenter la photographie d'un nouveau modèle de télescope, à miroir parabolique, en verre argenté, de M. FOUCAULT, et de vous donner la description de cet appareil en quelques mots qui suffiront pour vous faire apprécier les avantages de cette nouvelle construction.

Le corps de l'instrument est en cuivre poli et verni ; il est supporté par deux tourillons en acier, montés sur deux montants en fonte de fer, entre lesquels le corps de l'instrument passe librement ; ces deux montants reposent sur un pied-de-biche en fonte de fer, qui peut se placer sur une table, en sorte que l'horizon et le zénith peuvent être interrogés dans tous les sens par l'observateur assis ou debout.

Le chercheur, placé près du miroir, est d'une manœuvre facile pour le pointage astronomique.

Le grossissement varie, suivant trois jeux d'oculaires, de 80 à 300 fois, ce qui permet d'observer Mercure, Vénus, Saturne, les étoiles doubles, les montagnes de la Lune, les taches du Soleil, les nébuleuses, etc.

Cet instrument, très-portatif, qui fait aussi bonne figure dans un salon que dans un cabinet de physique, peut remplacer un télescope sept à huit fois plus volumineux et coûtant trois fois plus.

Le prix de ce Télescope complet est de . . . . . 500 francs.
Renfermé dans une boite en noyer. . . . . 25 fr. en plus.

En espérant, que vous voudrez bien m'accorder votre confiance, que je m'efforcerai de justifier,
J'ai l'honneur de vous prier d'agréer, Monsieur,
l'assurance de ma parfaite considération.

ED. LUTZ.

PARIS. — IMPRIMERIE DE E. MARTINET, RUE MIGNON, 2

Figure 89: Printed letter sent to potential customers in the 1870s advertising Édouard Lutz's "New model" 10½-cm Foucault telescope (courtesy: R. Smeltzer).

fication ..." of plane and curved surfaces was offered in 1885 (Duboscq, 1885: 112). The following year the Duboscq firm was taken over by Philibert Pellin (1847–1923; Brenni, 1996b). The Pellin catalogue for 1900 reprinted the engraving shown in Figure 51 and offered 100-, 160- and 200-mm "Foucault mirror" telescopes for 490, 1,200 and 2,000 fr respectively (Tables 3 and 4).

The case of the manufacturing optician Édouard Lutz, born in Riga in 1832, is intriguing. On 8 November 1883 he wrote to Flammarion, reminiscing:

> … the first Foucault *télescopes* were built in my firm, in the time of my predecessor, Mon-

> sieur Berthaux, and under the orders of Monsieur Foucault himself, as well as with Monsieur Fizeau's help, and that since this time (1852–53) I have worked to improve and simplify the design … and facilitate portability … (Fuentes, pers. comm., 2015).

The dates 1852–1853 are clearly wrong, and Lutz's claim that the first Foucault telescopes were made by his predecessor is not substantiated by Foucault's writings. Nor is Lutz's spelling certain: at death, his predecessor was recorded as Antoine Sedelly Bertaud (1802–1862) (Registre d'État Civil, 1862). One of Bertaud's specialities was cutting crystals. He certainly cut glass and crystals for Fizeau (e.g. Fizeau, 1862: 440). Perhaps he also cut the Iceland spar for Foucault's polarising prism in 1857, i.e. the time when Foucault was beginning his telescope work, and this is the origin of Lutz's confusion. Other —much later—authors claim rather that Bertaud was already using a system of local corrections in his work, and this was the inspiration for Foucault's *retouches locales* (d'Ocagne, 1904: 398; Laussedat, 1875: 1287; 1901: 125). Whatever the truth, the company was well-prepared to take up Foucault's ideas.

It is unclear when Lutz took over the Bertaud firm,[60] but he did produce a catalogue in his own name in 1872, in which he offered Foucault photometers and polarising prisms as well as "Foucault system" reflectors with exactly the same diameters, focal lengths and prices as offered by Duboscq in 1864 (Table 4). Was Lutz onselling Duboscq wares? Several facts suggest it may have been the inverse. Lutz's catalogue included a novelty not listed by Duboscq—a "Foucault telescope – M. Bourbouze's arrangement" with an accessory achromatic lens (Table 4).[61] In various ways this 'Swiss-army-knife' instrument could serve as projector, refractor, microscope (using the eyepiece assembly) or photographic camera! At about the same time Lutz sent potential customers a printed letter advertising a "New model" 10½-cm Foucault *télescope* with a pasted-on photograph (Figure 89).[62] In modified forms, this telescope appeared in later catalogues produced in 1882 and c.1890 (Tables 3 and 4). Figure 90 shows the associated engraving. At the Paris Exposition Universelle in 1878 Lutz showed a Foucault-type mirror. (At the same exhibition the Radiguet company exhibited an equatorial *télescope* with a mirror finished by one of the Henrys (Garnault, 1878: 475).) In 1890 Lutz gave one of his 16-cm reflecting telescopes to the Société astronomique de France (Armelin, 1890). Lutz died in 1895 (Registre d'État Civil, 1895), and subsequently similar 15-, 13- and then 10-cm instruments were offered in catalogues dated from 1907 to 1928 by Les Fils d'Émile Deyrolle, a firm better-known for biological supplies (Figure 90; 1907: 72; 1910: 110; 1928: 105).[63] Figure 91 shows what appears, on account of the longer collar fixing the altitude trunnions to the tube, to be a surviving Lutz instrument in Athens.

The previously-mentioned Bardou firm was founded in 1819 (see Table 3, 1899 catalogue)

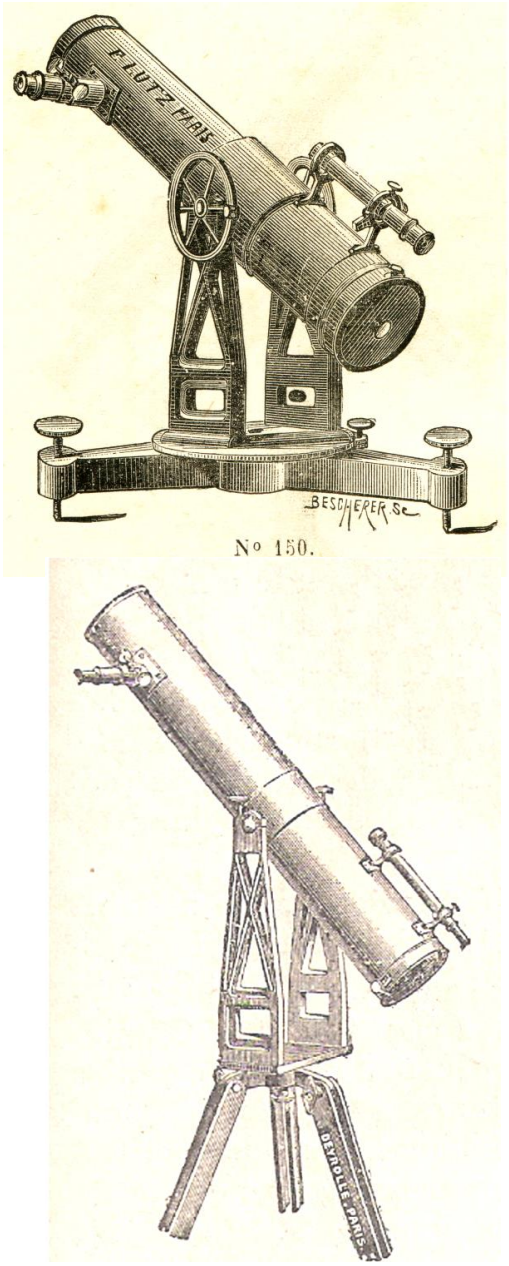

Figure 90: (Top) Engraving of Lutz Foucault-system telescopes from the firm's 1882 and c.1890 catalogues (Table 3). (Bottom) A similar style of telescope offered by the Deyrolle firm in the early twentieth century (after: Les Fils d'Émile Deyrolle, 1928: 105; courtesy: P. Brenni).

and towards the end of the century became an important supplier of small refractors, advertising frequently in Flammarion's monthly *Astronomie* magazine in the years around 1890.[64] Advertisements in 1888 and 1890[65] announced the availability of a catalogue, which I have not been

Figure 91: Remnants of what is probably a Lutz 4-*pouce* reflector (courtesy: Museum of Science and Technology, University of Athens).

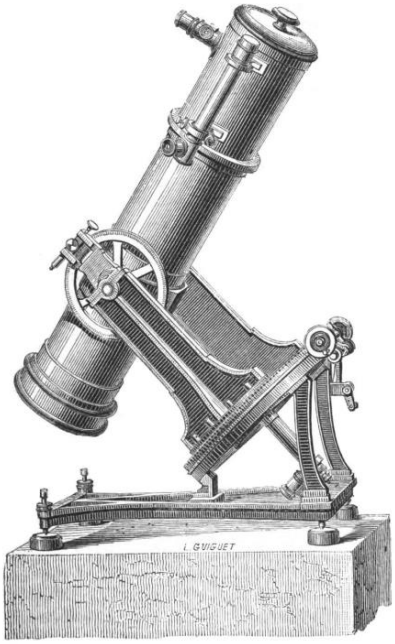

Figure 92: Woodcut of equatorially-mounted 10- to 20-cm reflecting telescopes printed in the 1892 Bardou catalogue (Tables 3 and 4) (after: Towne, 1896: 287; courtesy: Google Books).

Figure 93: A 20-cm reflector, conserved by the Istituto Leone XIII in Milan which from comparison with Figure 92 appears to have been supplied by the Bardou company. The Istituto was founded in 1893, so the telescope perhaps dates from after then (courtesy: P. Brenni).

able to find, with "Télescopes à miroir Foucault" as a category. A Bardou catalogue dated 1892 offered 10-, 16- and 20-cm alt-azimuth and equatorial *télescopes* (Tables 3 and 4), illustrated with woodcuts. For the alt-azimuth instruments, Secretan's original xylograph from 1865 was reproduced (i.e. Figure 51), though recut by another engraver, Louis Guiguet, who also provided the equatorial illustration shown in Figure 92. (These two woodcuts were also printed in practical astronomy books written by Gélion Towne (1890; 1896).) Figure 93 shows what is no doubt a 20-cm example of such a Bardou equatorial in Milan, though the instrument is unsigned. Figure 94 shows an ~f/7 alt-azimuth with an 108.7 ± 0.2 mm full-diameter mirror (i.e. essentially 4 *pouces*) stamped "A. BARDOU, PARIS". Denis Albert Bardou (b. 1841) says he took over from his father in 1865 (Légion d'honneur, 1892) and the instrument presumably dates

Figure 94: 4-*pouce* telescope belonging to the Lycée Janson de Sailly in Paris. The inset shows A. Bardou's name stamped at centre rear of the mirror cell (author's photographs).

from between then and his death in 1893 (Registre d'État Civil, 1893). Although the optical layout is basically the same as for a Foucault-Secretan telescope, the mounting does not conform to that illustrated in Figure 51 and the Bardou catalogues. The tube has a prominent brass ring at its mouth and is attached to the elevation axis by two plates rather than an encircling band. The Bardou stamp is surprisingly discreet compared to the exuberant signatures found on many A. Bardou refractors, raising the question of whether the Figure 94 telescope really was made by Bardou or on-sold from another manufacturer. However the form of its prism mount (Figure 95) is the same as for the Milan instrument, supporting the Bardou firm as the manufacturer of both telescopes. Nevertheless, why do the 1892 and 1899 catalogues illustrate the Secretan mount from 1865? Was this to save engraving fees, or did the firm just on-sell Secretan telescopes in the 1890s? After Albert Bar-

dou's death the firm was taken over by J. Vial, and by 1899 (Tables 3 and 4) had ceased offering equatorial *télescopes*.

Ducretet & Lejeune (1893) and Ducretet (1905) offered a 10-cm instrument with cast iron mounting, tripod, four eyepieces, finder and solar filter for 600 fr. A direct-vision spectroscope and equatorial mount were available as extras.

We have seen that R. Mailhat left the Secretan business to set up independently in 1894. His c.1908 catalogue and the c.1913 catalogue of his successor Francis Mouronval[66] (1881–1954) both reprint Figure 51 and offer a range of alt-az and equatorial silvered-glass reflectors with surprisingly-small size increments (Table 4). An advertisement from c.1913 offers a telescope which looks in many ways similar to Figure 51, except that it has an equatorial mount which is adjustable in latitude (Figure 96; Mouronval, 1911). A wood-mounted telescope at the Musée

Figure 95: Prism arm of the Janson de Sailly 4-*pouce* telescope. The arm in the Milan telescope (Figure 93) is similar, and provides a distinguishing feature from Secretan instruments (e.g. Figures 17, 46 and 57) (author's photograph).

des Confluences in Lyon is attributed to Mailhat, with the date range 1857–1868 (Figure 97; Musée des Confluences, 2009: 50). The date range is improbable, but not the attribution since the c.1913 catalogue adds "We also make … telescopes with a simplified mount, with a wooden mount, etc." (Mouronval, c.1913: 17).

Individual amateur astronomers also made silvered-glass telescopes, which in general are easy to identify because they do not match authenticated Foucault-Secretan designs. However, opticians sold mirrors on their own, which could then be mounted by amateurs. Secretan furnishes examples in 1874 (Appendix 2) as well as 1878a, c.1898, 1906a and 1915 (Table 1). A certain L. Cotessat ran an advertisement in 1890 offering 29-cm parabolized silvered-glass mirrors for 125 fr (Cotessat, 1890). Silvered-glass mirrors were also offered by Apoil (1904),[67] Mailhat (c.1908), and Mouronval (c.1913). An example of a self-mounted mirror is provided by the lunar

Figure 96: Mailhat-Mouronval advertisement showing a Newtonian reflector on a variable-latitude mount (cf. Table 4). The tube and fork resemble the Foucault-Secretan design from 1865 (Figure 51) (after: Mailhat and Mouronval, c.1913; courtesy: Google Books).

Figure 97: Wooden-tubed telescope attributed to "Ateliers R. Mailhat 1857–1868". The dates are improbable, because though similar to Foucault-Secretan wooden tubes, there are differences of detail (such as the round wooden mirror cell and the form of the fork) and the Mailhat firm dates from 1894 (after: Musée des Confluences, 2009: 50).

observer Casimir Marie Gaudibert (1823–1901; Obituary, 1901) who in about 1871 bought a 216-mm (8-*pouce*) primary mirror and an elliptical secondary mirror from an "... optician of the first rank ..." (who might or might not have been Secretan, given the focal ratio of *f*/7.6) and mounted it himself (Gaudibert, 1886: 375). Another example is furnished by Troubetzkoy (1917) who mounted or remounted a 10-*pouce* Secretan-Henry mirror (Figure 98). The possibility thus exists that a non-Secretan mount might contain a Secretan or even a Foucault mirror.

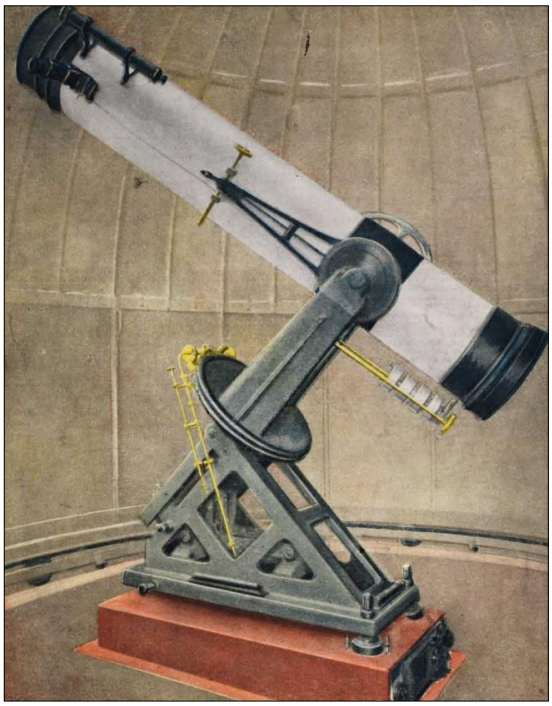

Figure 98: Equatorial Newtonian telescope incorporating a 10-*pouce* Henry-Secretan mirror. Troubetzkoy (1917) says he mounted the mirror himself, and the base is similar to a variable-latitude one invented by him (Troubetzkoy, 1919). However the tube and declination controls show many similarities with Foucault-Secretan instruments (cf. Figures 51 and 82) (after: Troubetzkoy, 1917; courtesy: introni.it).

11 HOW MANY TELESCOPES?

According to Babinet (1858), *Le Magasin Pittoresque*, the magazine that published the engraving of Foucault's first commercial telescope (Figure 9) had a circulation of 90,000. How many sales of non-professional telescopes may have resulted?

The disappointing answer is, not many. Taking the first design of 4-*pouce* mirrors mounted in a square wooden tube, the known serial numbers range from 2 to 42 (Table 6). For 10-cm mirrors in metal mountings the range is 13–236, and since the values for larger diameters fall within this range too, it seems that there may be only one sequence of numbers for metal mounts (Table 9). These serial numbers are to be compared with those on Secretan refractors, which towards the year 1900 could reach 2,306 (Wolf, 2014: FRA4), and even as high as 3,700 (Marine et Instruments Scientifiques, 2012). We can therefore expect sales of some tens for the first design and the low hundreds for metal-mounted silvered-glass *télescopes* compared to the several thousand refractors sold by the Secretan company.

Corroboration for these low numbers of reflectors comes from enumerations of public and private observatories published by Flammarion. In 1877, only the Marseilles 80-cm is listed explicitly as "... built by Foucault ..." (Flammarion, 1877a). The characterization "... Foucault *télescope* ..." applies to instruments in private hands: two 16-cm telescopes, one owned by Hippolyte Barnou, the architect of Flammarion's future observatory at Juvisy-sur-Orge, who used it to help Flammarion produce a corrected edition of Dien's *Atlas Céleste* (Flammarion, 1877b), and the other, equatorially-mounted, by a former naval officer, a Monsieur Le Roux de Villars; Flammarion's own telescope at his then-home on the Avenue de l'Observatoire, described as a 20-cm instrument (i.e. not the 16-cm seen in Figure 71), and another of the same size belonging to Dr E.M. Lescarbault (1814–1894) of Vulcan notoriety;[68] and a 40-cm instrument belonging to the wealthy Ghent sugar-refiner Adolphe Neyt (1830–1892).[69] Soon afterwards, Flammarion noted that "... several ..." 10-cm telescopes had been mounted as "... highly precise ..." equatorials (Flammarion, 1882: 685) and signalled a 10-cm Foucault reflector at the newly-founded Zacatecas Observatory (Flammarion, 1884). By 1890, Lescarbault was listed as also having a 30-cm Foucault *télescope,* Flammarion said he owned both 16- and 20-cm ones, and a Monsieur D. Raffard in Gien possessed a 10-cm one (Flammarion, 1890: 858–861). A 135-mm Lutz reflector was owned in Bayonne by Émile Daguin (1844–1930), son of the aforementioned P. A. Daguin (Section 6.2; Flammarion, 1930). A handful of other *télescopes* is listed without mention of origin, although at least the two belonging to Jules Thore of Dax were of Secretan manufacture: the 30-cm Henry reflector mentioned in Section 9.1, and a claimed "... $0^m.15$ ... " instrument (no doubt 16 cm, Table 9), both now at the Observatoire de Dax (Soulu, pers. comm., 2016). The original dust cap has survived for the latter, and attaches via a pair of rotating fingers, as seen also for Flammarion's 16-cm telescope (Figure 71, right).

I have no information as to whether instruments produced in the twentieth century were numbered. The 1942 Secretan catalogue uses an engraving to illustrate the available reflectors (the same one as Figure 86, centre). Refractors are illustrated with photographs, so the lack of a photograph of a *télescope* suggests it was some

time since one had been made.

12 TWO CASE STUDIES

I now apply the findings of this paper to evaluate two *télescopes* recently advertised by dealers.

12.1 Cambi Casa d'Aste, Genoa

Figure 99 shows a reflecting telescope put up for sale in 2006 by an Italian auction house (Asta di Strumenti Scientifici, 2006). The instrument was described as a Herschel-type Newtonian telescope scope with a glass mirror and original multi-coloured cardboard dust cap, and a circular plane mirror to direct light to the eyepiece. The tube outer diameter and length were given as 18 and 98 cm, respectively; and the telescope was ascribed an English or French origin in the late eighteenth or early nineteenth century.

The optical arrangement is clearly Newtonian and not Herschelian. The presence of a glass mirror shows it must postdate 1857. The equatorial mount shows similarities with those shown in Figures 31 and 44, so I feel its author must have read Foucault's description of his procedures in the Paris Observatory *Annales* as well as Drion and Fernet's *Traité.* This makes the early 1860s the earliest possible date for its construction, and perhaps favours a French origin. However the difference in detail of the fork, mirror cell, brasswork etc., and the use of a secondary mirror show that it was not made by the Secretan company. Corroborating this conclusion is the ~*f*/8 focal ratio suggested by the ~12-cm size of the aperture, which is too slow for a Foucault mirror. The dust cap may be old, but given such items' propensity to damage and replacement, I am agnostic about its originality.

12.2 Galérie Liova, Paris

Figure 100 shows a *télescope* offered by a Parisian gallery in 2012–2013, and more recently auctioned at the Hôtel Drouot, where I was able to inspect it. It was described as built on Dobsonian principles, attributed to Marc Secretan, and dated to around 1840 (Joron-Derem, 2015: 55).

The telescope has an alt-azimuth mount and Newtonian optics, which are features of the ideas of John Dobson (1915–2014) for large, inexpensive, transportable amateur reflectors, but the association is anachronistic because Dobson's ideas date from the second half of the twentieth century and the instrument does not incorporate pyrex, teflon and other modern materials (e.g. Dobson, 1991; Sinnott and Dobson, 1980).

The telescope is unsigned, and I am unaware of any Secretan advertisement for alt-azimuth telescopes in octagonal wooden tubes, but there can be no doubt it originated in the Secretan work-

Figure 99: Telescope offered for sale by the Cambi Casa d'Aste auction house in 2006. For an assessment, see Section 12.1. Now in the collection of Fausto Casi, Arezzo (courtesy: Cambi Casa d'Aste, Genoa).

Figure 100: The telescope auctioned at the Hôtel Drouot in November 2015. For an assessment, see Section 12.2. (Top) Overall view. The base measures 360 × 362 mm. Unlike the de Romilly telescope (Figure 38), the slats composing the octagonal tube have no decorative step. Their exposed length is 930 mm. Now in the collection of Vivek Hira, New York (courtesy: galerie-liova.com). (Bottom left) Mirror cell and (bottom right) mirror dust slide (author's photographs).

stat mirrors during 1872–1873 for the Transit of Venus expeditions is described in Commission du Passage de Vénus (1877). With Eichens he also built a 40-cm Foucault-style siderostat for Lord Lindsay's Transit of Venus expedition (André and Rayet, 1874; Brück, 2004). See also Note 37.

52. The 1874 catalogue does not appear in the *Bibliographie de la France*. The publication date derives from a review published in March (Dufour, 1874).

53. For the Digne and Coimbra telescopes the location of the declination clamp differs from other comparable instruments (Figures 70 and 77 vs. Figures 45, 50 and 67). For the Digne instrument, at least, I suspect this is the result of inexpert reassembly at some juncture. The 180°–0°–180° scale on its declination axis is inappropriate for declination and the clamp index mark is misplaced by a few degrees from the equator. If the clamp were in the usual location the scale would read polar distance.

54. Because of the poor image quality, Gully did not realise that he had seen the (super) nova S Andromedæ. Libert (1902) (and the Rouen Observatory web-page www.astrosurf.com/obsrouen) claim that Gully used the 16-cm reflector for this missed discovery, but that Gully's instrument was a different one seems confirmed by several different references to its 20-cm size (Gully, 1885; 1893; Venus le jour de sa conjunction, 1887).

55. Mailhat (c.1908: 3) says he was "... called ..." to head Secretan's workshops in 1888, which is not incompatible with his actually taking charge on 1 January of the following year. Afterwards Secretan advertisements mentioned his name as workshop director (e.g. Secrétan, 1890; 1893). Albert Rellstab was a later workshop head (e.g. Présentations et admissions, 1897).

56. Mailhat (1909) gives 30, Faubourg Saint-Jacques as the Secretan workshop address in 1889. An advertisement from the previous year has it at 54, Rue Daguerre, hardly much further from the Observatory (Secrétan, 1888). The evidence for expropriation comes from Épry (1911a: inside cover) and the date from Secretan (1915: 5). Mailhat's new premises were plausibly opposite the expropriated ones, because an advertisement from the early 1900s gives as address "41–42, Boulevard Saint-Jacques ... (opposite: 30, Faubourg Saint-Jacques)" (Andrews, 1994: 196).

57. Presumably the ~0.5-μm layer of celluloid varnish tried at Meudon Observatory by Perot (1909), the efficaciousness of which is perhaps attested by the reprinting of the method in *L'Astronomie* (Pérot, 1911 'Gelatine bichromate' had earlier been used on the 33-cm and perhaps 80-cm Foucault telescopes in Toulouse (Izarn, 1894).

58. Google Books snippet views reveal such advertisements from 1949 to 1963. Advertisements through 1948 make no mention of Prin, nor do ones following the takeover by Morin in 1964.

59. Morin-Secretan continued to appear in *L'Astronomie* cover-page listings of "Informations, adresses utiles" until early 1968, i.e. a little after the merger with SRPI, but perhaps these insertions were arranged prior to the fusion with SRPI.

60. In a form filled in for the 1878 Exposition Universelle, Lutz states the firm was founded in 1828 and that he "Took possession ..." of it in 1862 (Lutz, 1878), which is the year of A.S. Bertaud's death. However, the firm traded under Bertaud's widow's name as late as 1870 (e.g. Dupin, 1870: 123). To add to the confusion, H. Duplouich (in L'Industrie Française des Instruments de Précision, 1901–1902: 154) claims that the firm was founded by Berthaud (with an 'h') in 1848, and that he, Duplouich, took over in 1896. This latter claim seems likely since Lutz died on 1 October 1895 (Registre d'État Civil, 1895). In 1847 an almanach refers to "Bertaud ...", which by 1855 had become "Bertaud j[eun]e ..." (Almanach-Bottin, 1855: 965; Annuaire générale, 1847: 539). Perhaps between 1847 and 1855 A. S. Bertaud took over from a father or brother.

61. P. Fuentes (pers. comm., 2015) owns an *f*/6 Lutz reflector with a useful diameter of 125 mm but a 135-mm mirror with a convex rear. Is this a 125-mm instrument as advertised in Lutz's catalogue? Jean-Gustave Bourbouze (1825–1889) was a talented physics technician at the Sorbonne. He devised and manufactured a host of demonstration apparatus. I have no evidence that would corroborate the claim by the notoriously unreliable Louis Figuier (1890) that Barbouze collaborated with Foucault.

62. The letter is bound in the same volume as the 1858 Secretan catalogue 'Addition' (Table 1), but is not digitized at hathitrust.org. Lutz's 1882 and c.1890 catalogues equate 105 mm with 4 *pouces*, so the 10½-cm designation may or may not have indicated a change from the 108 mm advertised in the 1872 catalogue (Table 4).

63. The 1928 catalogue describes the instrument as having a 10-cm mirror and 80-cm

length, which is plausible when compared to the 85-cm length stated for the Lutz 10½-cm instrument (Figure 89). Apart from the diameters, the entries in the 1907, 1910 and 1928 catalogues are identically-worded, but 80-cm lengths would imply very fast focal rations for 13- and 15-cm mirrors. Misprints in diameters and/or lengths seem probable.

64. Harvard University Library holds volumes 1–9 (1882–1890) and 11–13 (1892–1894) of *L'Astronomie: Revue Mensuelle d'Astronomie Populaire, de Météorologie et de Physique du Globe.* The covers of the individual monthly issues have been retained in the bound volumes which are available (with difficulty) via Google.

65. Every issue in 1888 except December, for which the cover is missing, and July 1890. I have been unable to examine covers for 1891 (see Note 64).

66. "Mouronval" bought the firm in 1909 (Ventes de fonds de commerce, 1909: 1117). I have found references in 1911 and 1913 to the firm as "Mailhat & Mouronval Frères" so it appears that Francis Edmond's twin brother Pierre Paul (1881–1956) was associated with the firm, at least briefly (Adresses relatives aux appareils décrits, 1911; Mailhat and Mouronval Frères, 1913). The Mouronvals advertise their training at the École Polytechnique; the matriculation registers available at bibli-aleph.polytechnique.fr confirm that no other Mouronvals attended the school.

67. A copy of this rare pamphlet is preserved in the Paris Observatory Archives (Ms 1133-2 Frères Henry. Échanges avec des fabricants d'optique).

68. Lescarbault and Foucault may plausibly have been acquainted with each other, since in their medical studies both passed *externe* in the same year, 1843. Of the 124 candidates passed, Foucault was ranked 18th, Lescarbault 124th (Conseil Général des Hospices Civils de Paris, 1842).

69. If Flammarion intended to signpost Foucault-Secretan telescopes, I suspect he is mistaken concerning Neyt, whose famous lunar photographs—which admittedly date from a decade earlier—were taken with Browning-With silvered-glass reflectors of 9¼ and 10¼ English-inch clear aperture (e.g. De Vylder, 1877; Neyt, 1869).

70. From photographs it appears that a "SECRETAN A PARIS" signature was even applied *along* the length of the tube of a 16-cm metal-mounted alt-azimuth instrument offered recently by a fraudulent Uruguayan seller (Petrunin, pers. comm., 2015). This telescope is not included in Table 9.

71. For example, Moigno (1859c) states that he facilitated the acquisition of a Foucault telescope by the fabulous Bancker collection in Philadelphia (e.g. Simpson, 1995). What became of this instrument? It is presumably not the Smithsonian Institution telescope (Table 6), which was purchased in October 1979 from a dealer in Paris (Roux-Devillas, 12 Rue Bonaparte – S. Turner, pers. comm., 2015).

72. For an example of what might be done, see Hill (2005). The scientific papers inventoried after Foucault's death (see Tobin, 2003: xii) cote 11ème pièce 118 record "Secretan circular concerning his new model of reflecting telescope." Possibly this document advertised the 10-cm metal-tubed telescope.

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