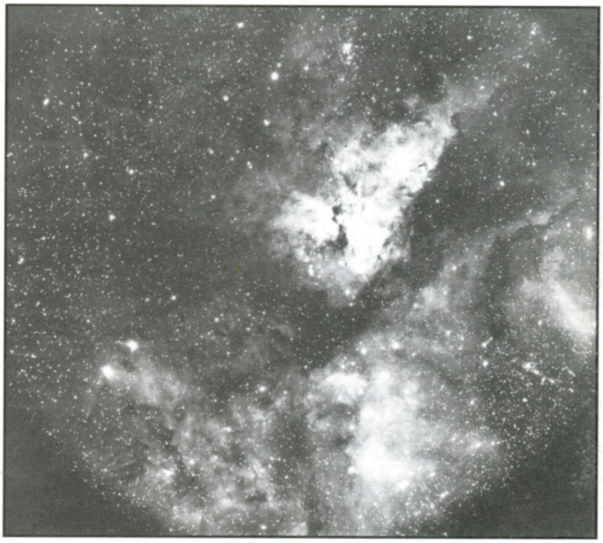
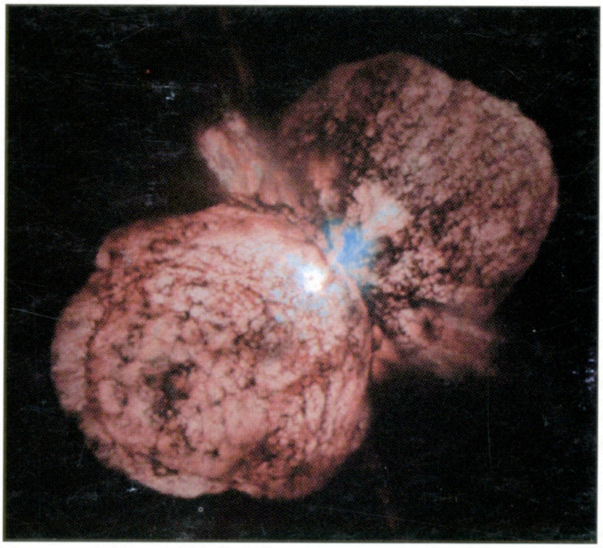
Journal of Astronomical History and Heritage



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"An Event Of No Ordinary Interest" – The Inauguration of Albany's Dudley Observatory

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Abstract
The Inauguration of the Dudley Observatory was a watershed in mid-nineteenth-century American science; most American scientists of any note attended the event, which took place in Albany in 1856 August at the close of the Annual Meeting of the AAAS. New York artist Tompkins Matteson's painting of the event, which includes more than 160 portraits, has been widely reproduced; however, an accompanying identification key created decades later is quite erroneous and misleading. A new key, which identifies 58 of the country's leading scientists and New York business and political figures, has been prepared, and, in conjunction with what is currently known about the painting's history, is detailed. Dudley Observatory's plan to sell time to New York cities and railroads was highlighted at the inauguration ceremony; an engraved marble tablet linking the electrical clock depicted in Matteson's painting to the facility's mean-time distribution system is discussed.

Key words: *Dudley Observatory, timekeeping, U.S. Coast Survey, Lazzaroni, AAAS*

1 INTRODUCTION

> The inauguration of two institutions of science at the capitol of our state – yesterday the Geological Hall, to day [sic] the Dudley Observatory – is an event of no ordinary interest. "

With these words of context former New York governor Washington Hunt (1856) began a eulogy for Charles Edward Dudley, successful merchant and banker, on 1856 August 28. Twice mayor of Albany, U.S. Senator, and member by marriage of one of the city's prominent families, Dudley had died fifteen years before. In recognition of his merit and early interest in astronomy, and through the munificence of his widow, Blandina Bleecker Dudley, an enterprise for the advancement of astronomical science was being launched.

It had taken more than five years to arrive at this beginning. Possibly inspired by the mid-century lectures of Ormsby MacKnight Mitchel, charismatic director of the Cincinnati Observatory, a group of Albany's business and political elites decided to include an astronomical observatory in their plans for a national university. Receiving Mitchel's encouragement, they met with him in August of 1851, the astronomer selecting a suitable site and providing a ground plan for the observatory building. Then, having secured considerable support from Mrs. Dudley, the Albanians approached members of the New York legislature. On 1852 April 3 an Act incorporating "The Dudley Observatory, of the City of Albany" was passed (New

York, 1852a, 1852b, 1852c). With additional funds in-hand, these citizens, now the Trustees of the Dudley Observatory, oversaw the building's erection. Begun in the spring of 1853 and completed in 1854, the structure was merely a shell: it contained no astronomical equipment at all. The Albanians had collected insufficient funds.

Lack of funds had also prevented the hiring of Ormsby Mitchel as the Observatory's director – although the astronomer did agree to serve in a titular capacity for a year or so. Benjamin Apthorp Gould, Jr., of Cambridge, who had received his Ph.D. in astronomy from the University of Göttingen under Carl Friedrich Gauss, was approached. He refused the post.

Attempts to put this very visible white elephant to work continued. During the summer of 1855, physician James H Armsby, Secretary of the Board of Trustees and the one who had first advanced the idea of an astronomical observatory, travelled to Providence, where the American Association for the Advancement of Science (AAAS) was holding its annual meeting. Armsby, one of Albany's most successful institution builders, met with two important and influential scientists: Alexander Dallas Bache, great-grandson of Benjamin Franklin and Superintendent of the U.S. Coast Survey, the agency responsible for charting America's coasts; and Harvard professor Benjamin Peirce, the country's leading mathematician. Also at this private meeting was Gould, Coast Survey Assistant and responsible for the agency's longitude-differences programme.

Years earlier, Bache, Peirce, and Albany-born Joseph Henry, Secretary of the Smithsonian Institution, had advised the city's leaders against the erection of an under-endowed observatory unable to support a strong programme in astronomical research. But with an empty building in place, an anxious trustee before them, and a long-standing technical challenge occupying their immediate attention, the scientists altered their stance.

Despite a dozen years of effort, the Coast Survey found itself unable to define the longitude between Greenwich Observatory and Harvard College's Cambridge Observatory to an accuracy better than two seconds (time). Its two astrometric methods for determining longitude – lunar culminations and stellar occultations – were in conflict, despite each showing results precise to a few tenths of a second (time). Indeed, the Survey's contract with Harvard astronomer William C Bond's family firm to conduct transatlantic chronometer transports had made matters worse, for this third precision method disagreed with both the astrometric ones (Bartky, 1999).

Given this intolerable state of affairs, Superintendent Bache asked Peirce to review all methods. The mathematician concluded that occultations was likely to be the most accurate one, but advances both in observations and theory were necessary. He recommended that the Survey focus its resources on occultations of the Pleiades. However, Bache informed Peirce that the enormous cost of the required telescope far exceeded the flexibility he possessed with regard to the Coast Survey's budget. So at the AAAS's Providence meeting, Peirce (1856) closed his paper on the subject with, "This labor will be greatly relieved by a new determination of the places of the Pleiades, and there seems no instrument capable of such delicate work as the heliometer. It is much to be desired, therefore, that this important instrument may be obtained for one of our observatories."

With such a propitious alignment of needs, a bargain was rapidly struck. Board of Trustees vice-president Thomas A Olcott convinced Mrs Dudley to fund the purchase of a heliometer. The Trustees agreed to accelerate their canvassing efforts in order to secure an endowment sufficient to operate and maintain this nascent research institution, now slated for national fame and international influence. In exchange, Superintendent Bache promised to assign trained observers to the Observatory after the heliometer had been installed. Beginning immediately, Coast Survey staff would aid in selecting the necessary scientific equipment.

The Observatory's trustees also created a technical advisory body – the Scientific Council – its members Henry, Bache, Peirce, and Gould. Astronomer Gould, though continuing at the Coast Survey, accepted responsibility for bringing the Observatory into working operation. All involved agreed on a target date: the third Wednesday of the following August, the opening day of the Tenth Annual Meeting of the AAAS, with Albany the venue.

Benjamin Gould failed to meet this optimistic goal; in fact, the astronomer never brought the Dudley Observatory into operating condition. Though he was self-assured at the Inauguration, his deadline became a moving target, always a distant point in time. Finally, more than two years after the ceremony and six months after his dismissal as director, Gould was ejected from the Observatory site by direction of a group of enraged trustees.

That tale of the Observatory's first years has already been told in a compelling social-history framework (James, 1980, 1987). What follows here is an account of two artefacts resulting from the Dudley Observatory's formal inauguration before a large group of American scientists, New York and Albany business and political leaders, and a vast throng of Albany citizens. One is a large painting of the Inauguration, the other a white marble tablet inscribed, "The Gift of ...", with the name of the erstwhile donor gouged out.

2 THE VISUAL RECORD OF THE INAUGURATION

No study of the painting could have been undertaken had the Dudley Observatory's inauguration not been linked to the Tenth Annual Meeting of the AAAS, whose daily sessions were held in the chambers of the capitol. Albany's leaders opened their homes to the scientific visitors and the receptions honouring the city's distinguished guests, including one given by Mrs Dudley, became the social events of the summer. The eight days of talks and lectures; the State Geological Hall's inauguration; and the Dudley Observatory Inauguration, which followed the last session, were featured in local and regional daily newspapers, in a New York weekly (Leslie, 1856a, 1856b, 1856c, 1856d), and elsewhere (Maverick, 1856; Pruyn, 1856). The two ceremonies took place inside an enormous tent that the city erected in Academy Park, close by the capitol. An estimated four-to-seven thousand citizens attended the Dudley Observatory's inauguration.

2.1 The Artist and his Painting

The Observatory inauguration was depicted by Tompkins Harrison Matteson, who is known for his paintings of historical, patriotic, and biblical subjects. Named after the then-governor Daniel D Tompkins, Matteson (1813-1884) enjoyed a successful career in New York city, where he was a member of the National Academy of Design. He continued painting after he moved to Sherburne, Chenango County, New York. Among his civic duties there Matteson represented his district in the New York State Assembly from 1855 to 1857 (Sherburne Art Society, 1949).

The artist's signed and dated, 56 × 72 inch oil-on-canvas work, the Inauguration of the Dudley Observatory, was completed in 1857 (Figure 1). Matteson did not title his painting, which has been identified as the "Dedication of the Dudley Observatory" in the art historical literature. In our view, that title is inappropriate, for it does not connote the public status of the facility at the time of the ceremony (Dudley Observatory, 1856; Munsell, 1856:307).

The Inauguration's origins and its early history are obscure. Nothing is known regarding Matteson's patron; perhaps one of the Observatory's trustees, or Mrs Dudley herself, commissioned the work. Presumably the painting was finished soon after the artist completed a term in the New York State Assembly and returned to Sherburne.[1]

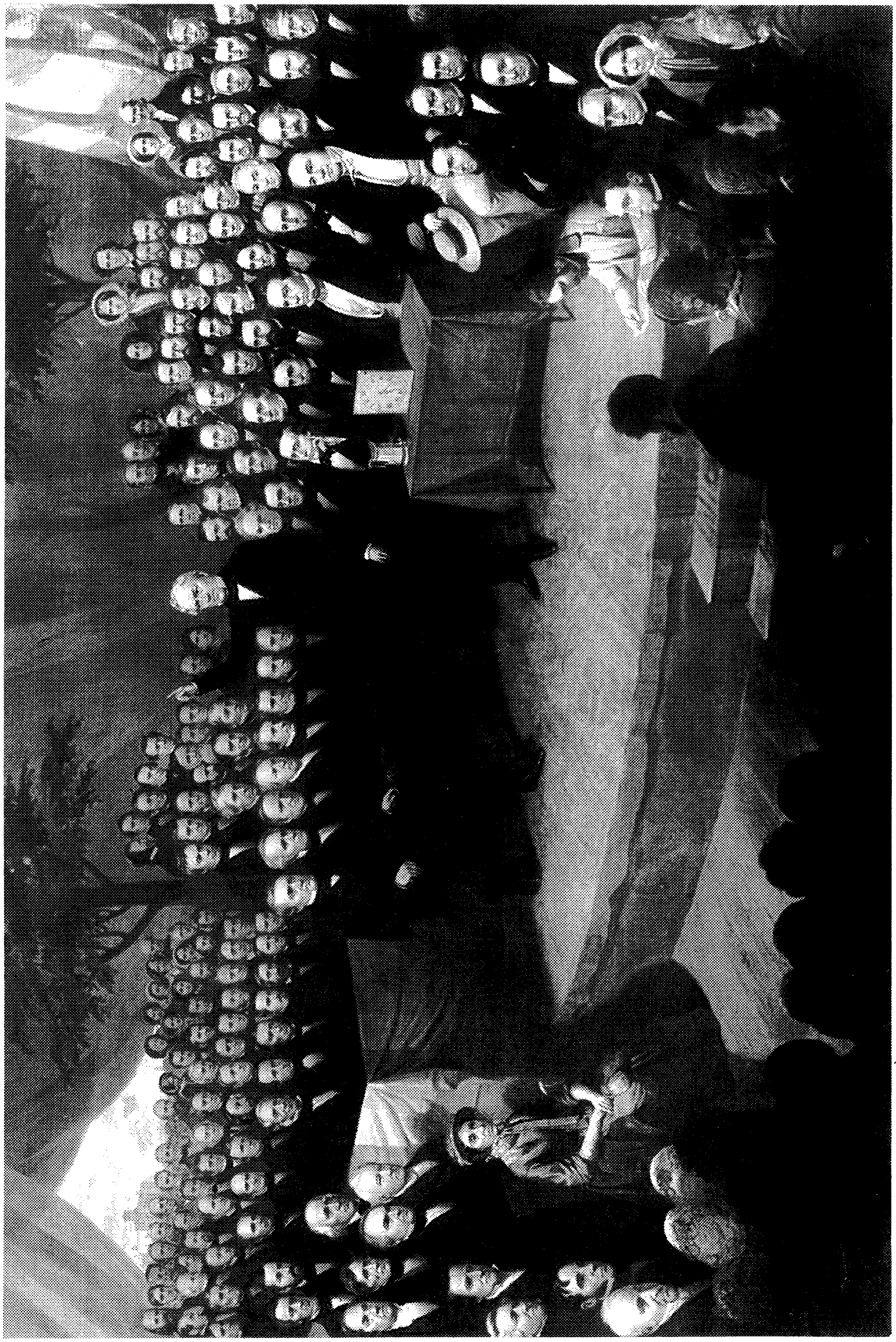


Figure 1. Tompkins Matteson's *Inauguration of the Dudley Observatory*, oil on canvas, 1857. Courtesy of the Albany Institute of History & Art, Albany.

Where the Inauguration was hanging in its first years is also unknown; no mention of it has been found in the Records of the Dudley Observatory Board of Trustees: 1852-1943. Around 1866, George Washington Hough, the Observatory's third director, prepared a description of the building and its siting, the telescopes and ancillary equipment, and his current observing programme. Even though he gave the precise locations of a marble bust of Charles Dudley, the portraits of Ormsby Mitchel and a second deceased Observatory astronomer, and the large tablets on which donors' names had been inscribed, Hough (1866:5-6) made no mention of Matteson's painting. However, an 1874 history placed it on the (south) wall of the library, the astronomer-author writing that Matteson's "portraits of the chief donors, and of the State and city authorities ... are said to be life-like" (Nourse, 1874).

During the 1890s the Dudley Observatory vacated its first site and moved all its equipment to a new building located on South Lake Avenue. In November of 1893 a second Observatory ceremony – a "dedication" – took place, the event coinciding with a scientific meeting held in the capitol by the National Academy of Sciences (1895).

According to its records, the Albany Institute of History & Art acquired the Inauguration in 1917 – a gift from General Amasa J Parker, son of one of the Albany notables depicted by Matteson. In 1958 the painting was lent by the Albany Institute to the Dudley Observatory; it hung in the Library until 1967, at which time the Observatory vacated the facility and moved to a building on Fuller Road, also in Albany. Returned to the Institute, the painting was conserved in 1970. Late in 1972 and into 1973, the Inauguration was included in "The Lazzaroni," an exhibit mounted by the National Portrait Gallery, Washington, and scheduled to coincide with the 139th Meeting of the AAAS (Lazy Ones, 1972; Miller *et al.*, 1972). In 1986 it was lent to the University Art Gallery, State University of New York at Albany, for a tricentennial exhibit, "Faces of the City." Currently the painting is on display at the Albany Institute.

2.2 Portraits in Matteson's Inauguration.

Matteson's painting is an icon of mid-nineteenth-century science, its importance defined by the scientists who attended the Inauguration.[2] The painting's central figure is statesman and popular orator Edward Everett, shown delivering his two-hour speech on "The Uses of Astronomy." On and around the speaker's platform are more than 160 people, sixteen of them female. Mrs Dudley is shown seated in the foreground.

After the Inauguration's acquisition by the Albany Institute of History & Art, attempts were made to find a record of the artist's placement of his subjects; however, these efforts proved unsuccessful. Subsequently, Institute staff members identified some thirty male and female images, locating them in terms of an x-y grid (Albany Institute, 1919). However, a number of the most prominent likenesses were not identified, and, with three or four exceptions, all those identified were affiliated with business, politics, and religion, not with science.

Geologist John Mason Clarke, New York State Museum director, sometime president of the Albany Institute and trustee of the Dudley Observatory, modified and extended this first key. In his key, Clarke (1923:322, 324) listed forty-two people, a dozen of them scientists, locating them via two truncated sketches of the painting. His results are the source for subsequent listings of those depicted in Matteson's Inauguration, these lists erroneously ascribed to the Frick Art Reference Library, New York city (James, 1987; Lurie, 1974). Unfortunately, Clarke's key is so riddled with errors that even the logic underlying the artist's creation has been destroyed.

2.3 Portraits of James Hall

We begin with Clarke's misidentification of Albany geologist and palaeontologist James Hall, who had been elected president of the AAAS, and at the opening of the Albany meeting he gave the traditional address. Near the end of the sessions, the inauguration of the Geological Hall, a renamed, renovated and enlarged State building scheduled to house Hall's extensive collections, was held. For Clarke, this ceremony on the afternoon prior to the Dudley Observatory's inauguration was the more important of the two. He even titled Matteson's work as the "Dedication of the Dudley Observatory and Geological Hall."

To illustrate his biography of Hall, Clarke included a lithograph from an engraving by Frederick Swinton (Figure 2a) that he captioned "James Hall President, American Association for the Advancement of Science 1856." Clarke used this image, which shows Hall with a full beard, to locate the geologist in Matteson's painting. However, the National Gallery of Art's collection includes Daniel Huntington's portrait of Hall, showing the famous geologist with a modest beard (Figure 2b). An 1857 date has been assigned to this portrait (Davis, 1996).

While reviewing the James Hall collection at the New York State Library, we chanced upon an unsigned carte-de-visite. In all respects save reversal, this photographic image (Figure 2c) is identical to Swinton's engraving of James Hall. Photographs in this format did not appear in the United States until *c.* 1860, so the Swinton lithograph can be no earlier than that date. Daniel Huntington's portrait must be the correct representation of James Hall in 1856; Clarke's identification of the full-bearded portrait in the Inauguration as Hall is wrong.

2.4 Misidentifications of three Scientific Council members

A few years ago, one of us (IRB) acquired an almost forgotten image of Alexander Dallas Bache (Figure 3).[3] It is identical to a person depicted in the Inauguration, even to the shadow on his shirt. Matteson's placement of this likeness – prominently in a front row – is entirely consistent with Bache's importance in the affairs of the Dudley Observatory, as well as in the event unfolding there. Clarke did not identify, or even sketch in, this portrait.

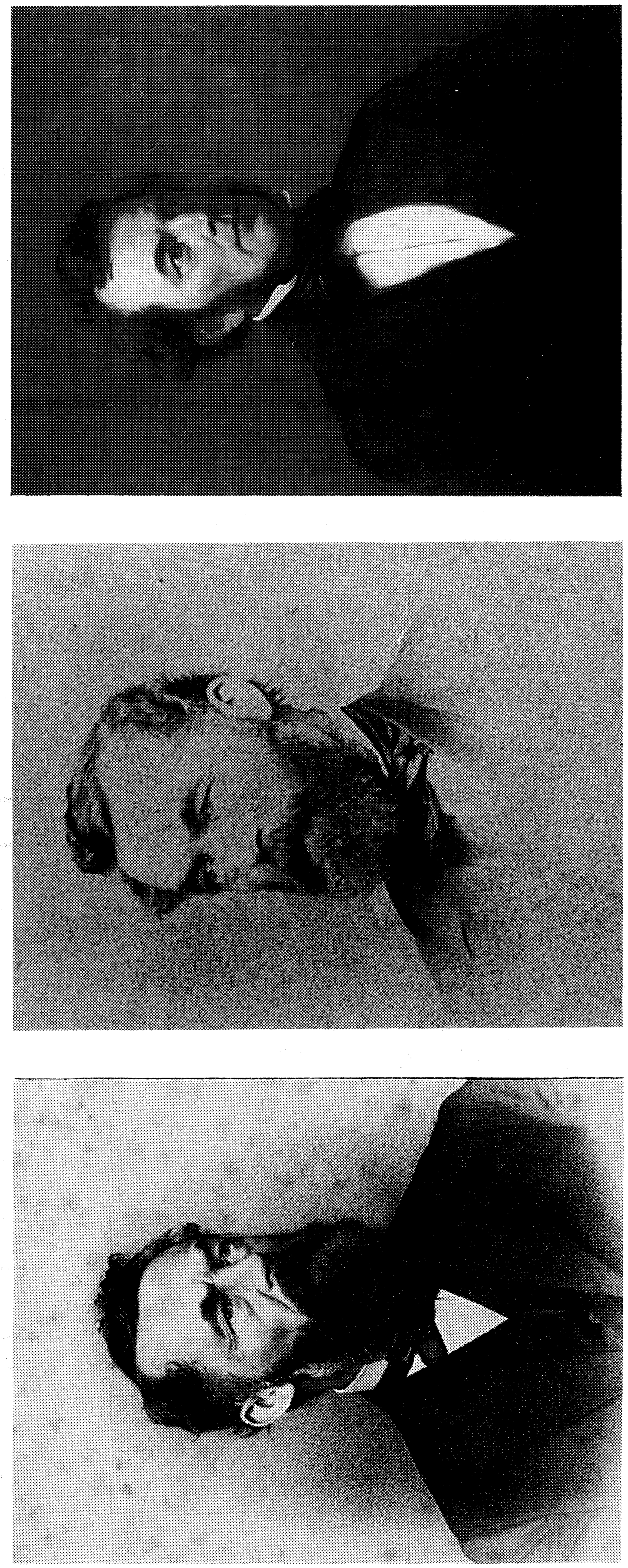
For Bache, Clarke identified the image of a man with a greying full beard, placed at the painting's far left side at mid-row level. Adjacent to it is another bearded man, identified earlier by the Albany Institute staff as Benjamin A Gould; Clarke used this particular identification in his key. Further, he identified a background image in the Inauguration as Benjamin Peirce.

Clarke's identifications of these scientists are illogical. Bache, Peirce, and Gould (Figure 4) were key participants in the affairs of the Dudley Observatory; at the Inauguration, Gould's and Bache's remarks followed Washington Hunt's eulogy. Any artist would have depicted such persons in prominent locations.

2.5 Mid-century American Scientists

In order to develop a more accurate key, we focused on scientists. We began with lists of members attending the 10th Annual Meeting in Albany. The AAAS's signature book contains 381 names; though not inclusive – for example, we did not find known attendee James D Dana's signature – its existence allowed us to correct the somewhat garbled and incomplete listings published in contemporary newspapers. Kohlstedt (1976:193, 201) has commented on such signature lists.

A decade ago Cornell University historian Robert V Bruce published his masterful history, *The Launching of Modern American Science, 1846-1876*. Although a few scientists within the time period have been the subject of detailed biographies, Bruce's work is one of the few providing a framework for an entire group of American notables in science – and thus is a gauge of their importance. We used Bruce's history as we winnowed the lists of AAAS members. We assumed that astronomers would have stayed in the city beyond the days of their sessions in order to attend the inauguration of an important observatory, and that, as a matter of course, the leaders of the AAAS were there as well.



a c b

Figure 2. James Hall, (a) lithograph by Frederick Swinton in the James Hall collection, New York State Library, Albany; (b) Daniel Huntington's Dr James Hall, oil on canvas, 1857, courtesy of the National Gallery of Art, Washington; (c) unsigned carte-de-visite, in the James Hall collection, New York State Library, Albany.

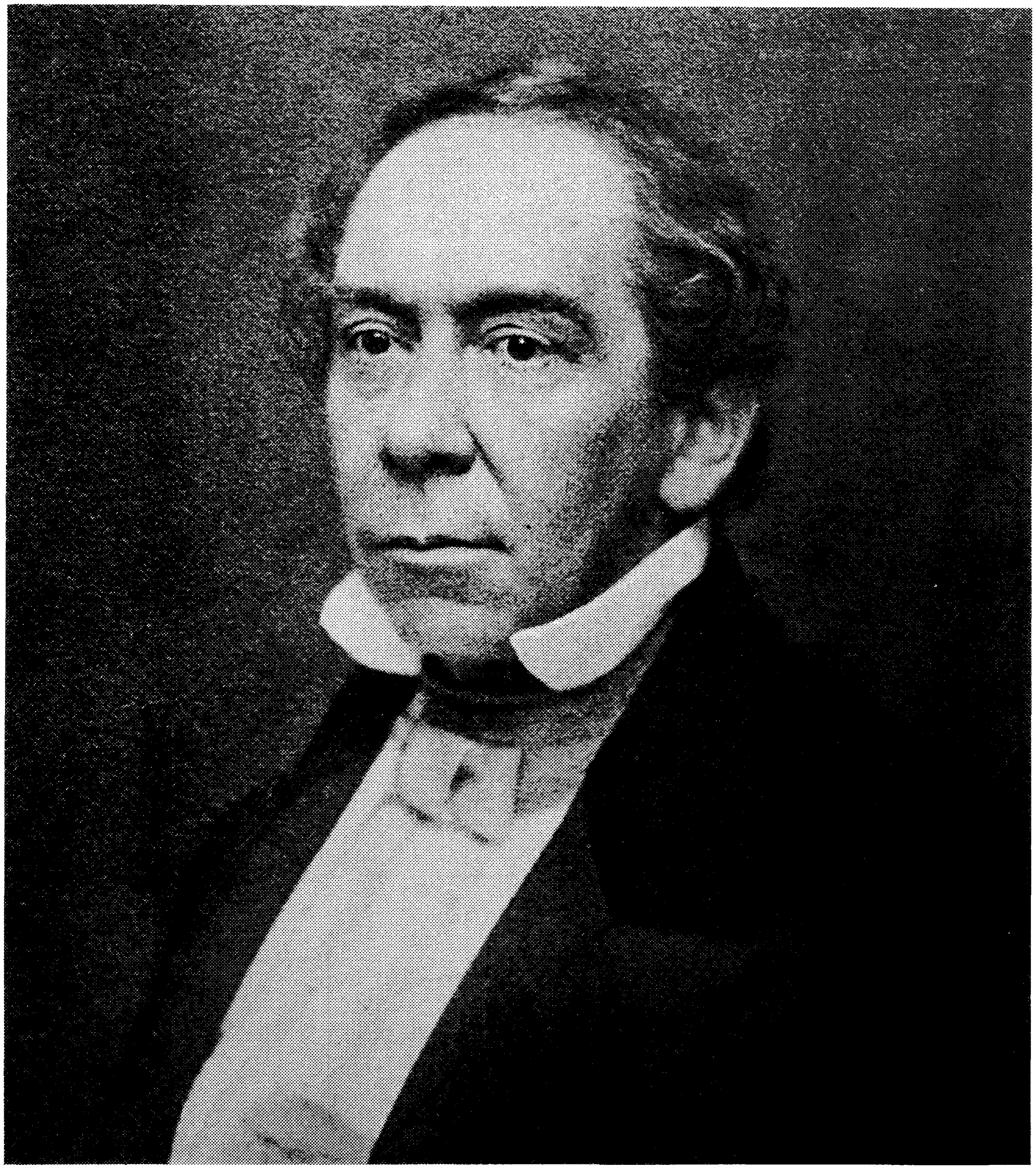


Figure 3. Alexander Dallas Bache (*c.* 1857), from the Mary Lea Shane Archives of the Lick Observatory, University of California-Santa Cruz.

We reviewed pictorial holdings at various American university archives, and selected photographic images taken within five or so years of the event. Some non-scientists attending the August 28 ceremony were important national figures. An examination of the image collections at the National Portrait Gallery and the Library of Congress led to the confirmation of several of the Albany Institute's earlier identifications.

We identified some fifty-eight of the portraits in Matteson's painting, thirty-six of them scientists and university administrators, located mostly in front rows and in the foreground. To display our results, we prepared an outline sketch (Figure 5); our numbering of the portraits differs from those in Clarke's sketches (and the numbers used in the 1919 key). In Table 1, the list of accompanying names, we have included the subjects' dates and their then-current affiliations.[4]

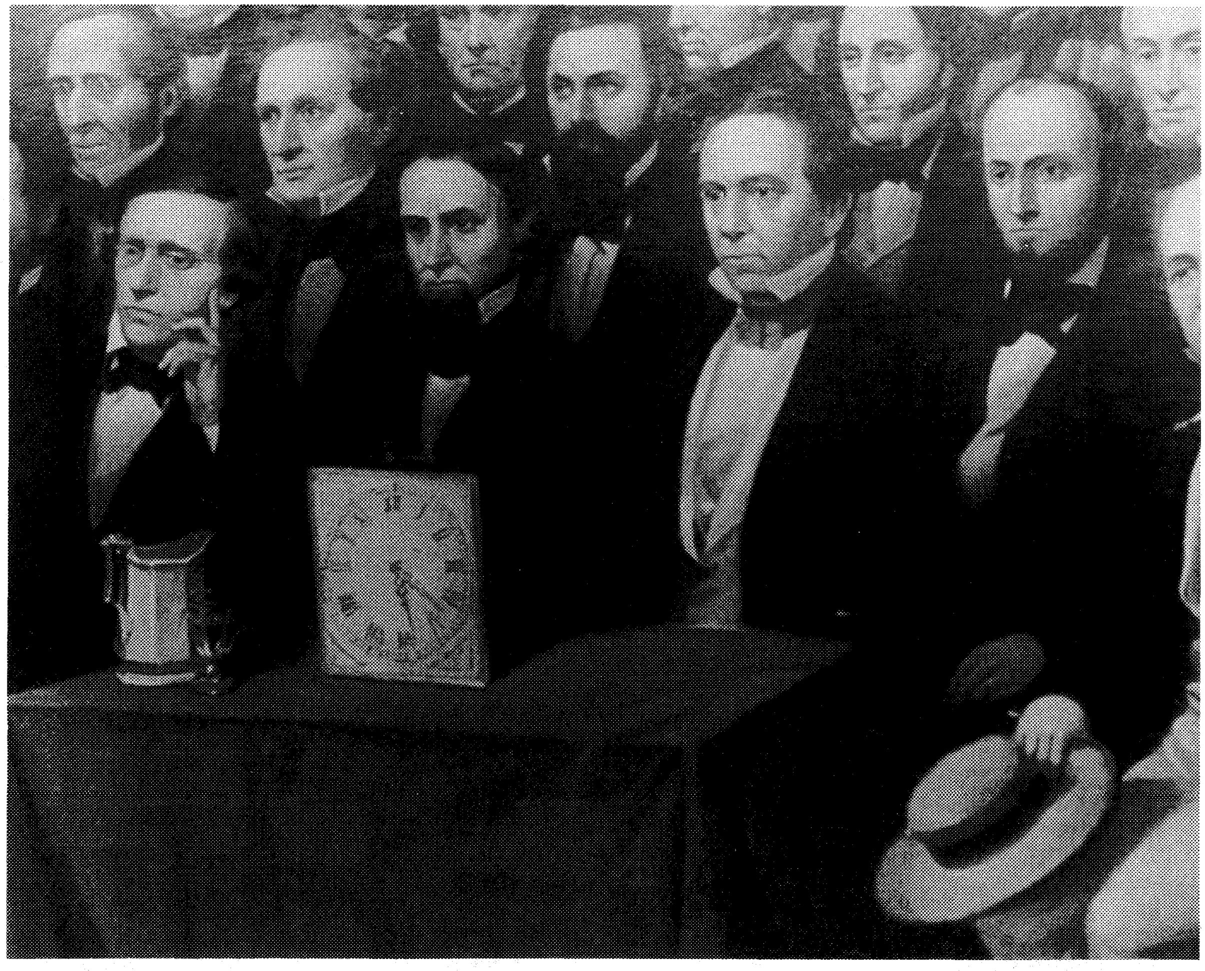


Figure 4. Detail from Matteson's *Inauguration*. Seated behind Moses Farmer's electrical-clock dial are, left to right, Washington Hunt, Benjamin Peirce, Alexander Dallas Bache, and Benjamin Apthorp Gould, Jr. Courtesy of the Albany Institute of History & Art.

2.6 The Artist's Approach

Although incomplete, our set of identifications sheds light on Matteson's plan for his canvas. First, the artist grouped his subjects: AAAS officers and scientists together, university and science administrators in a balancing row, and significant Albany and New York business and political figures in the foreground. (Some accounts describe the AAAS members entering the tent as an escorted group after the other notables had been seated, suggesting that a space on the platform was reserved for them.) Probably he worked entirely from photographs.

2.6.1 The Historical Record of the Inauguration

We believe the artist was deliberately creating a record. We have identified three images in the Inauguration as representing scientists who did not actually attend the Observatory's inauguration. They are University of the City of New York (now New York University) astronomer Elias Loomis, Yale College chemist Benjamin Silliman, Jr., and Matthew Fontaine Maury, Superintendent of the U.S. Naval Observatory. Their names are in square brackets in Table 1.

Lieutenant Maury's inclusion is of particular interest. In the public's eyes this naval officer was one of the country's most important scientists, his fame resting on the publication of his ocean navigation sailing charts. So great was his fame, and so significant his position as head of the country's so-called National Observatory, that he could not be excluded from this "picture-perfect" depiction of an event.

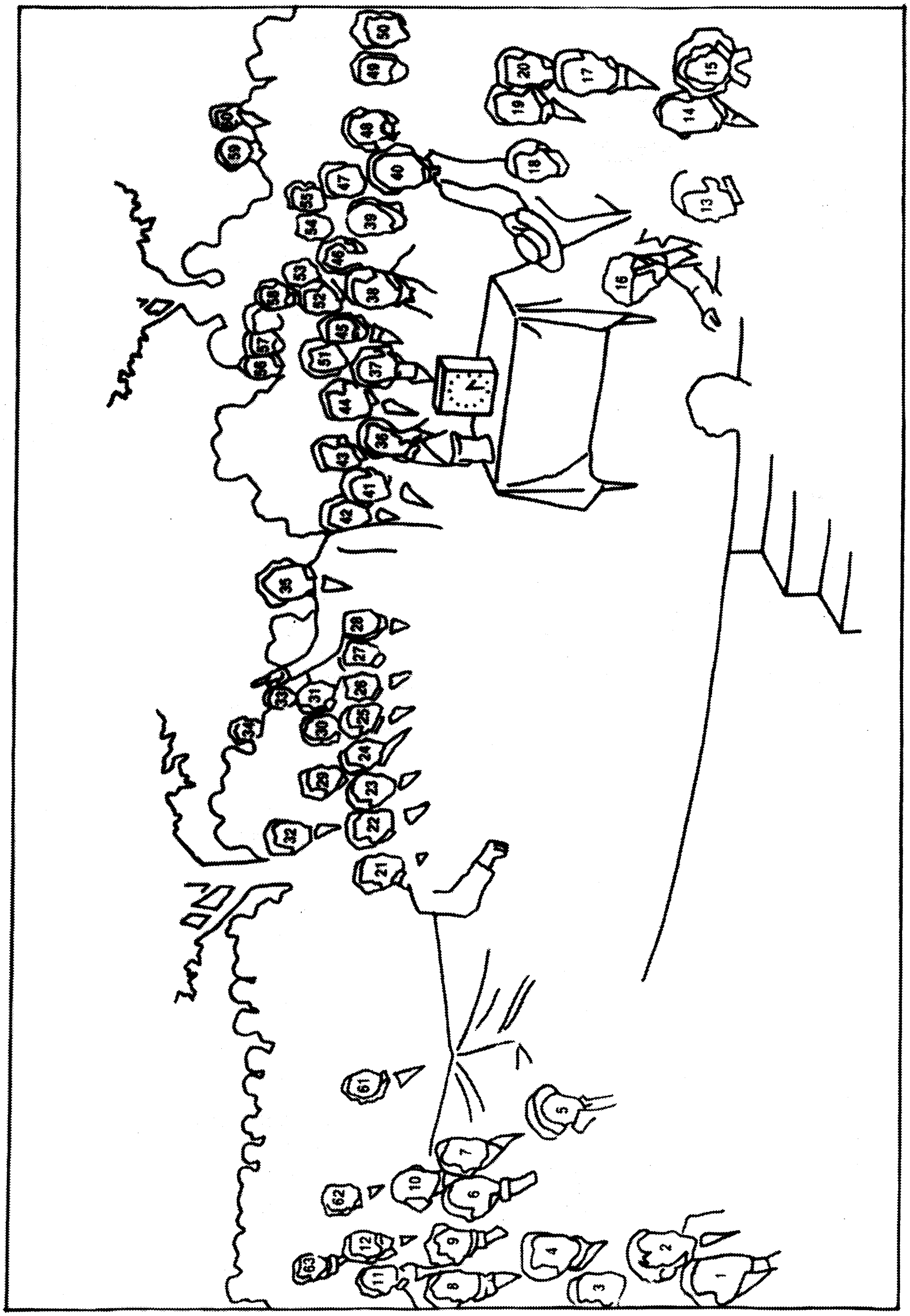


Figure 5. Sketch of Matteson's *Inauguration*, with numbered locations of identified portraits (see Table 1).

Table 1. Key identifying portraits in Matteson's Inauguration; locations are given in Figure 5.

No	Name	Dates	Affiliation
1	NOTT, Dr. Eliphalet	1773-1866	President, Union College
2	BARNARD, Daniel Dewey	1797-1861	Albany
3	FILLMORE, Millard	1800-1874	Former President of the United States
4	WYCKOFF, Rev. Dr. Isaac N.	1792-1869	Albany
5	DUDLEY, Blandina Bleecker	1783-1863	Widow of Charles Edward Dudley
6	OLCOTT, Thomas W.	1795-1880	Vice-President, Board of Trustees, Dudley Observatory
7	LANSING, Gerrit Y.	1783-1862	Chancellor, University of the State of New York
8	SPRAGUE, Rev. Dr. Wm. B.	1795-1876	Albany
9	PRENTICE, Ezra P.	1797-1876	Albany
10	HAWLEY, Gideon	1785-1871	Regent, University of the State of New York
11	ANDERSON, Martin B.	1815-1890	President, University of Rochester
12	Unknown-1		
13	PRUYN, Hon. Robert Hewson	1815-1882	Albany
14	CORNING, Erastus	1794-1872	Albany
15	CORNING, Harriet Weld	1793-1883	Albany
16	Unknown-2		
17	DEAN, Amos, LL.D.	1803-1868	Albany
18	ARMSBY, Dr. James H.	1810-1875	Secretary, Board of Trustees, Dudley Observatory
19	HARRIS, Hon. Ira	1802-1875	Albany
20	PARKER, Hon. Amasa J.	1807-1890	Albany
21	HENRY, Joseph	1797-1878	Secretary, Smithsonian Institution
22	SILLIMAN, Benjamin	1779-1864	Yale College
23	HITCHCOCK, Edward	1793-1864	ex-President, Amherst College
24	FERRIS, Isaac	1798-1873	Chancellor, University of the City of New York
25	ROGERS, William B.	1804-1882	State Geologist, Pennsylvania
26	MITCHEL, Ormsby MacKnight	1809-1862	Director, Cincinnati Observatory
27	[SILLIMAN, Benjamin, Jr.]	1816-1885	Yale College
28	TAPPAN, Henry P.	1805-1881	Chancellor, University of Michigan
29	WILKES, Charles	1798-1877	U.S. Navy, Washington
30	Unknown-3		
31	[MAURY, Matthew F.]	1806-1873	Superintendent, U.S. Naval Observatory
32	PRUYN, Hon. John V.L.	1811-1877	Albany
33	[LOOMIS, Elias]	1811-1889	University of the City of New York
34	BARNARD, F.A.P.	1809-1889	Chancellor, University of Mississippi
35	EVERETT, Hon. Edward	1794-1865	Orator and ex-U.S. Senator, Massachusetts
36	HUNT, Washington	1811-1867	ex-Governor, New York
37	PEIRCE, Benjamin	1809-1880	Harvard College
38	BACHE, Alexander D.	1806-1867	Superintendent, U.S. Coast Survey
39	GOULD, Benjamin A., Jr.	1824-1896	U.S. Coast Survey
40	AGASSIZ, Louis	1807-1873	Harvard College
41	HALL, James	1811-1898	State Geologist, New York
42	REDFIELD, W.C.	1789-1857	1st President, AAAS
43	LOVERING, Joseph	1813-1892	Harvard College
44	GRAY, Asa	1810-1888	Harvard College
45	GIBBS, (Oliver) Wolcott	1822-1908	Free Academy, New York
46	CHAUVENET, William	1820-1870	U.S. Naval Academy
47	Unknown-4		
48	GAVIT, John E.	1817-1874	Albany
49	LECONTE, John Lawrence	1825-1883	Entomologist, Philadelphia
50	HARE, Robert	1781-1858	University of Pennsylvania
51	DANA, James D.	1813-1895	Yale College
52	HORSFORD, Eben Norton	1818-1893	Harvard College

Table 1. Key identifying portraits in Matteson's Inauguration; locations are given in Figure 5 (Concluded).

No	Name	Dates	Affiliation
53	SCHOOLCRAFT, Henry R.	1793-1864	Ethnologist, Washington
54	COFFIN, John H.C.	1815-1890	U.S. Naval Academy
55	ALEXANDER, Stephen	1806-1883	College of New Jersey (Princeton)
56	BRÜNNOW, Franz F.E.	1821-1891	Director, Detroit Observatory, Ann Arbor
57	LECONTE, Joseph	1823-1901	Franklin College, Athens, Georgia
58	PETERS, C.H.F.	1813-1890	U.S. Coast Survey
59	MITCHELL, Maria	1818-1889	Astronomer, Nantucket Island
60	MITCHELL, William	1791-1869	Banker, Nantucket Island
61	Unknown-5		
62	SEYMOUR, Hon. Horatio	1810-1886	Ex-Governor, New York
63	BANCROFT, Hon. George	1800-1891	Historian and statesman, New York

Superintendent Maury's inclusion suggests that the Scientific Council had no influence on the work. Indeed, if Gould, Bache, and Peirce had ever viewed the completed canvas, they would have been displeased. They judged Maury a most inadequate scientist, and certainly not worthy of inclusion in any record of "their" event.

Logic suggests that the person in the painting seated between U.S. Navy officers Charles Wilkes and Matthew Maury is Charles Henry Davis, Superintendent of the Nautical Almanac Office in Cambridge, and a close friend and professional colleague of Bache. No record documents his presence in Albany during the period, and we were unable to locate any contemporary image of this important scientist. This likeness remains unidentified.

With regard to Albany and New York figures included in the painting but not present at the Inauguration, the lack of sources other than newspaper articles hinders further analysis. However, we note that former President Millard Fillmore – prominent in the painting – was not mentioned in these contemporary accounts. Additionally, there is an image suggestive of Senator William H Seward of New York, known to be in Washington during this August period. We predict that an analysis of political figures by some future art historian will enlarge our understanding of Tompkins Matteson's political intent.

2.6.2 The Dudley Observatory Building

In addition to depicting those notables who attended the Inauguration, Matteson included the Dudley Observatory building, showing it in good detail in the distance (Figure 1). This structure had been erected within an eight-acre site on the plateau of a high hill a mile north of the capitol. Starting in 1856, the building was extensively remodelled to accommodate larger-than-planned-for instruments. These changes, which were not completed until well after the Inauguration, altered the building's north and south exteriors. Nonetheless, contemporary writings and lithographs indicate an attractive structure, similar in basic style to many of that era's observatories – see Hough (1866), Leslie (1856d:201), and Munsell (1856:303-306). A before-1856 view of the Observatory building is in Loomis (1856) – undoubtedly the engraving used eighteen years later by Nourse (1874). A later photograph of the building is shown in Figure 6.

Matteson's depiction of the unfinished building was also part of his creative historical record, for the structure could not be seen from the site of the Inauguration. However, the two locations had been linked especially for the ceremony, and the artist documented this coupling in his visual recording of the day's events.

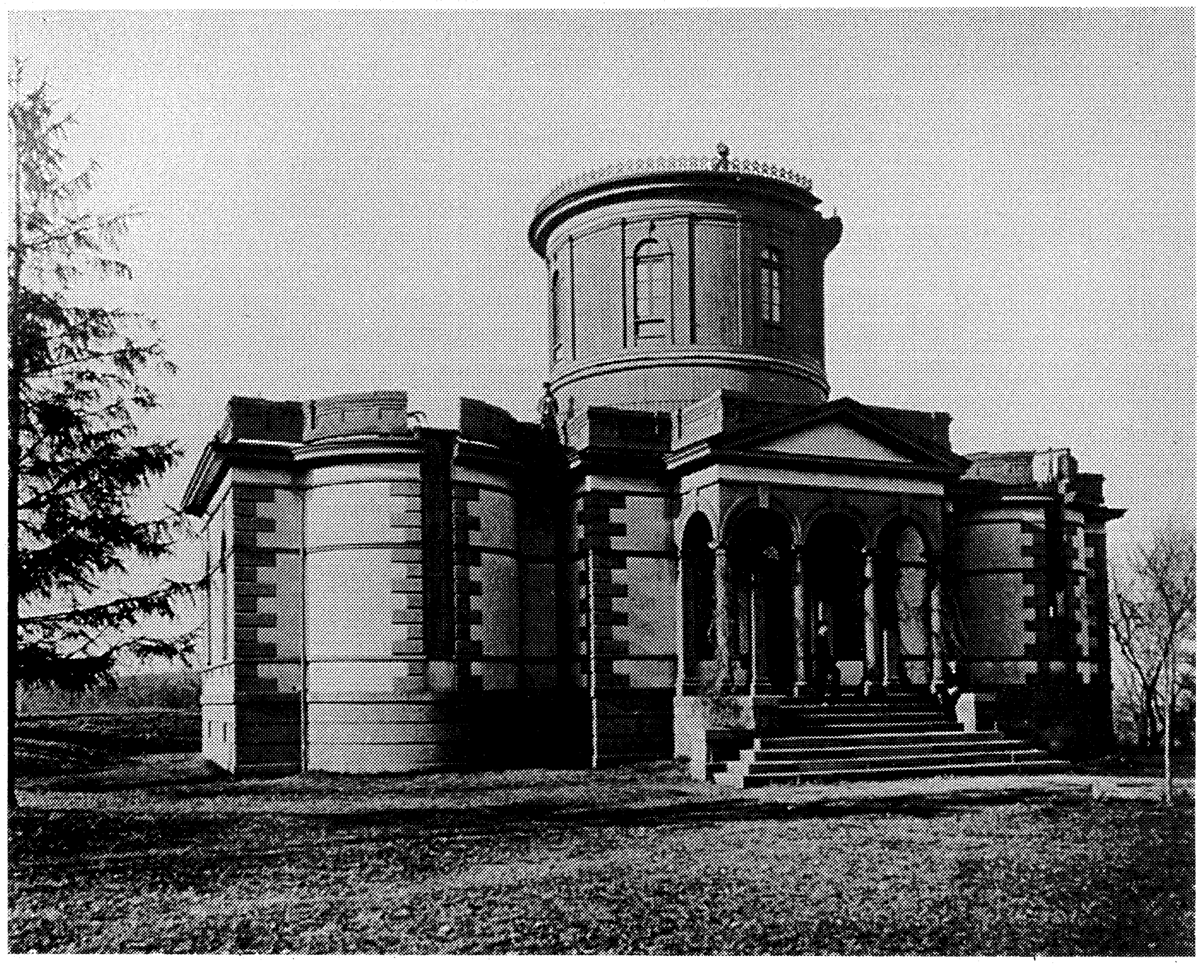


Figure 6. The Dudley Observatory, Albany, photograph taken after 1856.
Courtesy of the Trustees of the Dudley Observatory.

3 DUDLEY OBSERVATORY TIMEKEEPING: THE 'CORNING CLOCK'

All astronomical observatories must possess a clock displaying sidereal time. The funds for this absolutely vital piece of equipment were to come from Erastus Corning, arguably Albany's wealthiest citizen and one of its most powerful and politically influential businessmen (Neu, 1960). After the formation of the Scientific Council, and with the urging of his wife, Harriet Weld Corning, the financier and president of the New York Central Railroad agreed to transform an earlier pledge of $1000 into one for the purchase of the Observatory's timekeeper (Gould, 1855b, 1856b).

When in 1855 September Benjamin Gould sailed for Europe to contract for the construction of the Observatory's advanced telescopes, he also carried authority to purchase its *normal* (i.e., standard) clock. Journeying to Altona, Gould ordered a timekeeper far beyond the state-of-the-art. So at this moment in time the 'Corning clock' was an advanced astronomical regulator whose pendulum would be adjusted to sidereal time (Gould, 1855a).

3.1 Distributing Mean Time

During this European buying trip, Gould also visited the Royal Observatory at Greenwich. There he examined in great detail the mean-time distribution system that Astronomer Royal George Airy had been perfecting. Created and installed over the previous half-dozen years, this government-supported service allowed the distribution of time signals to London and more distant cities via the kingdom's commercial telegraph lines. Selected railroads were among the users. Undergoing further expansion at that moment, Airy's system so impressed the American astronomer that he immediately adopted it as the model for observatory public time services (Gould, 1855d). Already the Dudley Observatory's trustees and the Scientific Council had decided to sell Albany time to the railroads headquartered in Albany and New York, and, eventually, to cities along the New York Central Railroad's right-of-way across the state (Armsby, 1855).

Home from Europe, the astronomer took a logical, but ultimately disastrous step with regard to the specifics of timekeeping: he decided that the Observatory's mean-time system should be called the 'Corning clock.' In early January Gould (1856a) ordered an electrical pendulum and dials for displaying both mean and sidereal times at various stations within the Observatory's building.

Eight weeks before the Inauguration the issue of the Corning clock came to the fore once more, with Benjamin Gould's reminding James Armsby of the two clock systems for the Dudley Observatory. The astronomer noted that the one with its subsidiary dials displaying "solar (civil) time" would give Albany time "to the [New York Central] RR, so it will be best to call that [mean-time system] the Corning clock." Gould (1856d) requested Armsby's decisions with regard to the construction of a large marble clock dial for displaying Albany time, including where it and the separate driven-pendulum works should be placed in the building.

'Best', of course, is in the eyes of the beholder. Apparently, no one thought to inform Erastus Corning that his name would not be associated with one of the Observatory's primary astronomical instruments, its sidereal timekeeper. Instead, it had been relegated to a secondary time distribution system. Of course that system's Albany time – mean time – would be compared frequently with the Observatory's normal clock, and would be more than adequate for all public uses, including the running of trains. Nonetheless, without his knowledge, Corning's pledge had been reassigned to a commercial venture (Corning, 1858; Dudley Observatory Trustees, 1858:9).

All through July and into August Gould scrambled to ensure that the clock system would be completed and installed by the middle of the month. Armsby, who was also an active member of the AAAS's Local Committee, hurried about overseeing the myriad large and small tasks that had to be finished before the scientists arrived. One chore was the preparation of a marble tablet honouring the clock's donor, done under the close supervision of Albany engraver John E Gavit (Gould, 1856d).

On the day before the August 20 opening of the Annual Meeting, a just-completed clock was rushed to the Observatory building. The clock – actually a battery-driven pendulum invented by Moses Farmer (1852) of Boston – was the heart of the Dudley Observatory's commercial mean-time distribution system, and was America's state-of-the-art at that moment.

Farmer's electrical pendulum was installed in a wall niche in the Observatory's main hall. Mounted in another wall niche symmetric to it was a large marble clock dial, its hands driven by impulses generated via the pendulum's motion. Below the dial was placed a marble tablet inscribed, "The Gift of Erastus Corning." (This tablet is the second artefact associated with the Inauguration of the Dudley Observatory.)

A line of telegraph wire running from the Observatory building to the tent in Academy Park had already been erected (Gould, 1856c, 1856d, 1859:154, 211; Parker, 1857:235). When connected to the driven pendulum, it carried electrical pulses to a subsidiary clock dial – the one pictured in the Inauguration (Figure 4). Matteson showed the dial on a table in front of Peirce, Bache, and Gould. His choice may be an exaggeration, considering the fragile control wires and the claim made later that Gould turned "to a clock exhibited by Mr. Gavit upon the rear of the platform" (Dudley

Observatory Trustees, 1858:27). However, both its inclusion and placement near the painting's focus document the artist's awareness of the importance of timekeeping to the Observatory's fortunes.

3.2 Gould on Observatory Timekeeping

During his talk at the Inauguration, Gould (1856e) referred briefly to the Observatory's master timekeeper "ordered in Altona ... [which] will soon be here and described." He devoted many words to the "clock for mean time" with its "great marble dial, three feet square, which shows the Observatory time, beat by the beautiful electromagnetic pendulum," concluding these remarks with, "An elegantly engraved marble inscription below it commemorates the name of the donor." After mentioning the Observatory's new chronograph, a device for comparing clocks with star transits and other timekeepers, the astronomer concluded his description of the Observatory's timekeeping equipment with

> Dials in every room will telegraphically record [display] the time indicated by the normal clock imbedded in the massive pier below; while the Corning clock sends out the corresponding mean or civil time, to the north, south, east and west.

Ending his remarks with an appeal for operating funds, the astronomer summarized the Observatory's status, telling the thousands before him that the building's completion "needs but a few weeks," while adding, "By that time ... the clocks will be sending their mystic signals to all the dials, even as the Corning clock now ticks above my head." At that moment he undoubtedly also pointed to the subsidiary clock dial on the platform, its hands being driven by pulses from the mean-time pendulum situated over a mile away.

Certainly it was clear in Gould's mind that the mean-time clock in the Observatory was now the 'Corning clock'. Armsby, Secretary of the Board of Trustees, also understood the relations linking the normal clock, the mean-time clock and dial at the Observatory, and the subsidiary dial that Gould had just highlighted. In contrast, most of those attending the ceremony neither understood nor particularly cared about such differences: the working clock before them was being associated with the famous Albanian's name. And as the Inauguration became a distant memory for them, any Observatory timekeeper became the 'Corning clock'. Even most of the Scientific Council had trouble distinguishing between the two classes of timekeepers, still terming both of them the 'Corning clock' in mid-1858 (Henry *et al.*, 1858a; however, Henry *et al.*, 1858b).

4 AFTERWARD: 1856-1859

The Inauguration over, the Observatory's electrical pendulum was stopped; it had served its purpose, and would not operate again for almost three-and-a-half years. Efforts to bring the Observatory itself into operation continued, then slowed, and finally ground to an apparent halt. Frustration grew. Late in 1857 Gould, whose nominal title was "astronomer-in-charge," accepted the directorship of the Dudley Observatory, and the following February moved to Albany to focus on his charge. But it was too late; tensions between Gould and the Trustees multiplied. In early June, citing "want of harmony," a majority of the Observatory Board voted to dismiss him. Despite the decision, the astronomer refused to vacate the site (James, 1987:139-152).

A war of words began. In their pamphlet the Trustees (1858:24) summarized the astronomer's tenure: "Of all the splendid promises made by Dr. Gould ... not a single one was realized." Even Joseph Henry, Alexander Dallas Bache, and Benjamin Peirce – the astronomer's ardent supporters on the Scientific Council – could not deflect this reality.

The Trustees highlighted Gould's actions with regard to the many facets of Observatory timekeeping. One issue was the non-delivery of the Observatory's master timekeeper, which they termed "the Corning clock." They accused Gould of deceiving those at the Inauguration when he mentioned, not only "the Corning clock [which] now ticks above my head," but when he "turned significantly to a clock ... upon ... the platform."

Self-serving, clever, often inaccurate, and frequently hilarious, the Trustees' "Statement" outraged Gould and his supporters, who proceeded to enhance the genre of character assassinations with their own contributions.

4.1 Corning Repudiates "his" Clock

In December the Observatory's normal clock still had not arrived.[5] Undoubtedly judging (correctly) that it would never be delivered, Erastus Corning (1858), strong supporter of the Scientific Council, promised to honour his pledge "when the clock shall have been completed and placed in the Observatory." The financier added that he knew nothing about the mean-time clock and the inscription below it. Surely Gould winced when he read these remarks; in essence, they supported the Trustees' position.

Early in 1859 January the astronomer was finally removed from the Observatory; his addition to the war of words appeared a month later. Joining with the Trustees in dissembling, Gould wrote that they were "falsely implying that the Normal clock was known" as "the Corning clock." The record – in print as well as in correspondence – counters the astronomer's assertion (Gould, 1859:154, 213).

With Gould gone from the site, the Dudley Observatory was finally under the Trustees' control. Thomas Olcott, also a major benefactor and now President of the Board of Trustees, began the lengthy process that would finally lead to the inauguration of the Dudley Observatory's programme in astronomy. Banker Olcott, a long-time business and political rival of Erastus Corning, must have been furious at the latter's repudiation of the Observatory's mean-time clock system.

But by this time Congressman Corning must have been furious as well. He may even have requested formally that his name be removed from the mean-time clock. Clearly, the sequence of events occurring over the Observatory's next months will

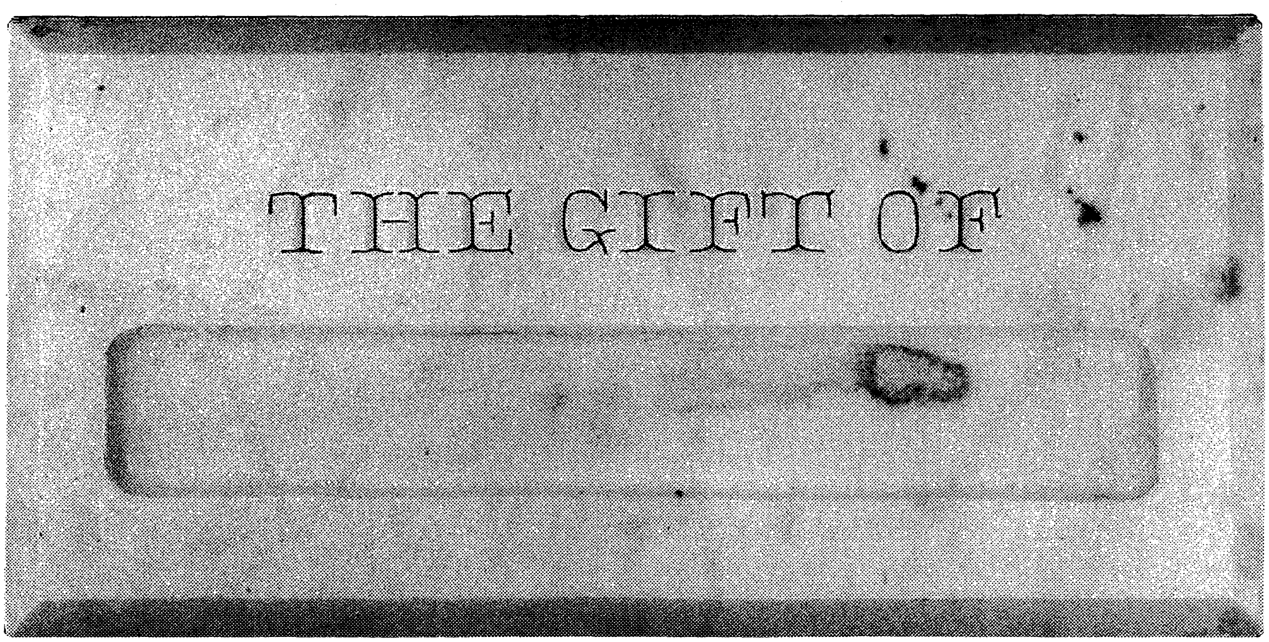


Figure 7. Clock donor's tablet. Approximate dimensions (inches): 12 3/4 by 7 3/4 by 1 9/16. Engraved 1856 August; text partially removed, *c.* 1859. Artefact is in the Archives of the Dudley Observatory. Courtesy of the Trustees of the Dudley Observatory.

never be known with certainty. Nonetheless, someone caused Corning's name to be gouged out of the marble tablet. Perhaps the now-altered tablet (Figure 7) was placed below the Observatory's clock dial once more, for all to see. Here, too, the record is silent.[6]

5 EPILOGUE

The first Dudley Observatory is no more, the site vacated, its building gone. Matteson's Inauguration hangs prominently in the Lansing Gallery of the Albany Institute, reminding us of that watershed in American science. The 'Corning clock' tablet remains, a symbol of technical and managerial naivety – as well as hubris. And as Mary Ann James's *Elites in Conflict* disclosed, the unfolding of this unhappy episode in mid-nineteenth-century American science serves as a constant reminder of the absolute need for mutual respect – "comity" in another context – between those who would use a scientific facility, and those who would fund it.

6 ACKNOWLEDGMENTS

Without Elizabeth H Bartky's research efforts, specific identifications, and continuous encouragement, this study would not have been possible. IRB acknowledges partial financial support via awards from the National Science Foundation, Washington, DC, and the Trustees of the Dudley Observatory, Schenectady, NY. Marc Rothenberg, Editor, Joseph Henry Papers, Smithsonian Institution, brought the issue of "contemporary" portraits of James Hall to our attention. Linda Thrift, Keeper, Catalog of American Portraits, National Portrait Gallery, Smithsonian Institution, opened the collection's supporting files and supplied numerous images; Kathleen Dorman, Assistant Editor, Joseph Henry Papers, made available her collection of images and provided many helpful suggestions; and Tammis Groft, Chief Curator, Albany Institute of History & Art, gave us access to the records of the Inauguration. Additional assistance came from Dorothy Schaumberg, Mary Lea Shane Archives of the Lick Observatory, University of California-Santa Cruz; the late Lillian B. Miller, Historian of American Culture, National Portrait Gallery; Patrice Donoghue, Assistant Curator, Harvard University Archives; staff at the Prints and Photographs Division, Library of Congress; staff at the Smithsonian Institution Archives; Administrator Ralph Alpher, Archivist Nancy Langford and Rita Spenser of the Dudley Observatory; Michele Aldrich, former Archivist, American Association for the Advancement of Science; Senior Curator John V Alviti and library staff at the Franklin Institute Science Museum; Deborah Chotner, Assistant Curator of American and British Paintings, National Gallery of Art; and Sally G Kohlstedt, University of Minnesota. Other libraries and archives whose staff responded to our requests are noted in the listing of comparison images. IRB thanks Steven Dick, U.S. Naval Observatory, and Donald Osterbrock, Lick Observatory, for their comments on an earlier version of this paper.

7 NOTES

1. In 1858 one R Van Dien asserted copyright protection on images of Matteson's Inauguration taken by the well-known New York city photographer, Charles DeForest Fredricks. The mount of the 16¾" by 12½" albumen print bears both their names and the title, "The American Association for the Advancement of Science./Inauguration of the Dudley Observatory." (Originals are owned by the Albany Institute of History & Art and the Dudley Observatory). Except for a passing mention by Kohlstedt (1976:117), Van Dien is completely unknown.
2. Matteson's painting is reproduced in Clarke (1923); forms the front and back covers of an important biography of Louis Agassiz (Lurie, 1974); is included in the seminal history of the AAAS (Kohlstedt, 1976); is reproduced in the history of the Dudley Observatory (James, 1987); and is prominent in the collage forming the cover of the 1998 February 6 *Science*. Along with the new identification key discussed in this study,

a copy of the Inauguration was part of "150 Years of Advancing Science," an exhibit unveiled at the 150th Annual Meeting of the AAAS in Philadelphia and subsequently displayed at AAAS headquarters in Washington.

3. The image is from the Mary Lea Shane Archives of the Lick Observatory, Santa Cruz, CA – one in a bound album of photographs and part of an extensive collection of nineteenth-century scientists assembled by Edward S Holden (1846-1914), Lick's first director. Printed underneath the subject original is "A. D. Bache." This image gave the first indication that Clarke's identifications were grossly in error.
4. A list of the specific images used in our comparisons, with estimated dates and current location, has been deposited with the Albany Institute of History & Art and the Keeper of the Catalog of American Portraits, National Portrait Gallery, Smithsonian Institution.
5. Since early 1858 the Observatory's sidereal standard was a borrowed astronomical regulator made by Edward Dent of London. Eventually donated by George W Blunt, partner in the New York nautical chart and instrument company of that name, the clock was modified by William Bond & Son, Boston, soon after Gould's ejection from the observatory site. The timekeeper continued as the Observatory's primary standard for many years, and is now at the New York State Museum, Albany.
6. Subsequent to this study, Dudley Observatory Archivist Nancy Langford brought to our attention an undated note appended to Erastus Corning's 1854 August pledge in the Albany Astronomical Observatory's subscription book: "This subscription was never paid. It was changed to an astronomical clock to cost $1000 which was ordered from abroad. But which order was countermanded, the clock never delivered & the inscription on the marble stone in the Hall of the Observatory in commemoration of the gift & the giver had in consequence to be removed."

8 REFERENCES

Albany Institute, 1919. Dudley Observatory Dedication [*sic*], August 28, 1856. In Chief Curator's files, Albany Institute of History & Art.

Armsby, J.H., 1855. Letter to B.A. Gould dated September 15. In A.D. Bache Papers, Manuscript Division, Library of Congress (Reel 1, #0066).

Bartky, I.R., 1999. *Selling the True Time: Nineteenth-century Timekeeping in America*. To be published by Stanford University Press.

Bruce, R.V., 1987. *The Launching of Modern American Science, 1846-1876.* Cornell University Paperbacks, Ithaca.

Clarke, J.M., 1923. *James Hall of Albany: Geologist and Palaeontologist, 1811-1898.* (2nd printing), Albany, pp. 317-324, and unpaged accompanying figures.

Corning, E., 1858. Letter to G.H. Thatcher dated December 3. Quoted in G.H. Thatcher, *A Key to the "Trustees' Statement". Letters to the Majority of the Trustees of the Dudley Observatory showing the Misrepresentations, Garblings and Perversions of their Misstatements.* From Atlas and Argus, Albany, pp. 117-120.

Davis, J., 1996. Daniel Huntington. In F. Kelly, with N. Cikovsky, Jr., D. Chotner and J. Davis, *American Paintings of the Nineteenth Century: Part I.* National Gallery of Art, Washington, pp. 334-337.

Dudley Observatory, 1856. *Inauguration of the Dudley Observatory at Albany, August 28, 1856.* Charles Van Benthuysen, Albany.

Dudley Observatory Trustees, 1858. *The Dudley Observatory and the Scientific Council. Statement of the Trustees*. [Charles] Van Benthuysen, Albany.

Farmer, M.G., 1852. Improvement in Galvanic Clocks. U.S. Patent No. 9279, 21 September.

Gould, B.A., 1855a. Letter to J.H. Armsby dated November 5. Quoted in Dudley Observatory Trustees, *Statement of the Trustees*, p. 11.

Gould, B.A., 1855b. Letter to J.H. Armsby dated November 22. Dudley Observatory Archives, Schenectady, New York; hereafter DOA.

Gould, B.A., 1855c. Letter to [J.H. Armsby] dated November 22. DOA.

Gould, B.A., 1855d. Letter to J.H. Armsby dated December 3. DOA.

Gould, B.A., 1856a. Letters to J.H. Armsby dated January 12 and February 4. DOA.

[Gould, B.A.], 1856b. Note. *Proceedings of the American Association for the Advancement of Science*, 9:102.

Gould, B.A., 1856c. Letters to J.H. Armsby dated July 2, 3, and 7. DOA.

Gould, B.A., 1856d. Letter to J.H. Armsby dated August 16 . DOA.

Gould, B.A., 1856e. Remarks. In *Dudley Observatory, Inauguration of the Dudley Observatory*, pp. 27-30, 32.

Gould, B.A., 1859. *Reply to the "Statement of the Trustees" of the Dudley Observatory.* Charles Van Benthuysen, Albany.

Henry, J., Bache, A.D. and Peirce, B., 1858a. *Defence of Dr. Gould by the Scientific Council of the Dudley Observatory.* 1st ed. Weed, Parsons and Company, Albany, pp. 55, 57.

Henry, J., Bache, A.D. and Peirce, B., 1858b. *Defence of Dr. Gould by the Scientific Council of the Dudley Observatory.* 3rd ed. Weed, Parsons and Company, Albany, p. 45.

Hough, G.W., 1866. Description of the observatory. *Annals of the Dudley Observatory*, **1**:1-8, and two unpaged illustrations.

Hunt, W., 1856. Eulogy. In *Dudley Observatory, Inauguration of the Dudley Observatory*, p. 5.

James, M.A., 1980. The Dudley Observatory Controversy. Ph.D. thesis, Rice University, Houston.

James, M.A., 1987. *Elites in Conflict: The Antebellum Clash over the Dudley Observatory.* Rutgers University Press, New Brunswick.

Kohlstedt, S.G., 1976. *The Formation of the American Scientific Community: The American Association for the Advancement of Science.* University of Illinois Press, Urbana.

The Lazy Ones. *Washington Star and News*, December 24 (1972).

Leslie, F., 1856a. Congress for the advancement of science. *Frank Leslie's Illustrated Newspaper*, August 30.

Leslie, F., 1856b. Members of the scientific convention in the Academy Park. *Frank Leslie's Illustrated Newspaper*, August 30.

Leslie, F., 1856c. Scientific convention. *Frank Leslie's Illustrated Newspaper*, September 6.

Leslie, F., 1856d. The Dudley Observatory, Albany. *Frank Leslie's Illustrated Newspaper*, September 6.

Loomis, E., 1856. *The Recent Progress of Astronomy; Especially in the United States.* 3rd ed. Harper & Brothers, New York, p. 281.

Lurie E., 1974. *Nature and the American Mind: Louis Agassiz and the Culture of Science.* Science History Publications, New York.

Maverick, A., 1856. *The Uses of Astronomy, an Oration Delivered at Albany ... by Edward Everett ....* Ross & Tousey, New York, pp. 3-11.

Miller, L.B., Voss, F. and Hussey, J.M., 1972. *The Lazzaroni: Science and Scientists in Mid-Nineteenth Century America.* Smithsonian Institution Press, Washington.

Munsell, J., 1856. Dudley Observatory. *The Annals of Albany* **7**:303-309.

National Academy of Sciences, 1895. Scientific session. *Report of the National Academy of Sciences for the Year 1893.* Government Printing Office, Washington, pp. 17, 19-20.

Neu, I.D., 1960. *Erastus Corning, Merchant and Financier: 1794-1872.* Cornell University Press, Ithaca.

New York, 1852a. *Journal of the Assembly of the State of New York at their Seventh-fifth Session.* Albany, pp. 658, 739, 853.

New York, 1852b. *Journal of the Senate of the State of New York at their Seventh-fifth Session.* Albany, pp. 130, 158, 354, 362, 478, 487.

New York, 1852c. *Laws of the State of New York, Passed at the Seventh-fifth Session of the Legislature.* Albany, chapter 150, pp. 195-196.

Nourse, J.E., 1874. Observatories in the United States. VII. Dudley Observatory. *Harper's New Monthly Magazine* **49**:526.

Parker, A.J., 1857. Welcoming address. *Proceedings of the American Association for the Advancement of Science* **10**:234-235.

Peirce, B., 1856. Method of determining longitudes by occultations of the Pleiades. *Proceedings of the American Association for the Advancement of Science* **9**:97-102.

Pruyn, J.V.L., 1856. Journal, pp. 168-170. Special collections, New York State Library, Albany.

Sherburne Art Society, 1949. *Thompkins* [sic] *H. Matteson, 1813-1884.* Sherburne, New York.

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Norman Rice is Director-Emeritus of the Albany Institute of History & Art. He is the leading expert on the history of Albany and its citizens.

Christine Bain is Associate Librarian at the New York State Library, Albany. For many years she was the Dudley Observatory's librarian, and, to our great fortune, became the 'keeper' of the second artefact discussed in this paper.

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Plato's theological astronomy
II. *The Laws* : an old man looking back

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Abstract
In *The Laws*, Plato considered astronomy as socially necessary but espoused a metaphysical model for the heavens, in which celestial motions were due to souls of gods. He furthermore reasoned against physical philosophers whose ideas he found dangerous for the youth. His views on astronomy and on the necessity "to ignore the visible heavens" have been vividly discussed over the last 150 years. For more than 20 centuries astronomy was characterized by the Platonic spirit, according to which there is no need for observations but only for metaphysical theories. However Plato was not actually concerned with astronomy and, by extension, natural sciences in general; his central interest focused on how to govern his perfect state.

Key Words: *Plato's* The Laws, *observational astronomy, evolution of astronomy, souls and motion, order*

1 INTRODUCTION

In a previous article, Sinachopoulos and Sinachopoulos (1991), we have dealt with astronomy in Plato's *The Republic* (Plato1), in an attempt to explain the philosophical and political tendencies of his times. In the present work, we turn our attention to Plato's *The Laws* (Plato3) insofar as Plato's position with respect to astronomy and, by extension, the natural sciences is concerned. In *The Republic*, a work probably completed around 390 BC (Taylor, 1978), Plato, 428-347 BC, at his intellectual peak, demanded that:

> We shall therefore ... ignore the visible heavens, if we want to make a genuine study of the subject [astronomy] and use it to convert the mind's natural intelligence to a useful purpose. (Rep 530b, see Section 10, Notes 1.)

The discussions on the meaning and the significance of this Platonic saying, as well as on the role of Plato in the evolution of astronomy, have been lively during the last centuries, (see e.g. in Bulmer-Thomas, 1984; Mourelatos, 1980), or even the reference to the criticism of Hume in (Meldrum, 1950). The interpretations of the Platonic work regarding astronomy and the evolution of natural sciences, as well as the related criticism, vary significantly, for example in (Donnay, 1960; Knorr, 1990; Lloyd, 1968; Mittelstrass, 1962; Mourelatos, 1981; Neugebauer, 1957; Solmsen, 1977); some interpretations consider Plato very important for the evolution of astronomy since, according to these, he advocated a theoretical examination of the universe in much the same spirit as that of geometry. Other interpretations, including those of the authors of this work, express the opinion that Plato's teaching significantly hindered the development of natural sciences instead.

In his final work, *The Laws*, written in his old age, around 350 BC (Taylor, 1978), Plato retains his faith in a metaphysical interpretation of the world: he considers the physical world as contradictory and incomplete, the stage for constant creation, change and decay, hence unfit to be the object of scientific study. While *The Republic* treats astronomy only as far as its subject matter is concerned, which for Plato is completely unrelated to whatever is visible in the heavens (Rep 530c), his *The Laws* lay the foundations of, and fully expound, a theological view of astronomy (see also the Table of Section 11), according to which the stars and all the other visible heavenly objects are simply the divine souls of virtuous beings. In *The Laws,* the main points regarding astronomy concern the role of astronomy in communal life, the dangerous ideas of the physical philosophers, the regularity in the motion of the heavenly bodies, and, finally, the divinity of the celestial objects.

"It has always been correct to praise Plato, but not to understand him" commented Russell (1972). One of the main objectives of this work is to help understand the Platonic work, the Platonic way of thinking and some of the obstacles scientists have had to face during the centuries.

2 *THE LAWS*: GENERAL PRESENTATION

In *The Laws*, the main speaker is no longer Socrates as in *The Republic* and other Platonic dialogues but an anonymous Athenian debating, with the Cretan Cleinias as well as the Spartan Megillus what kind of legislation could lead the citizens of a town to ultimate virtue (630c; see Section 10, Notes, 1.). We follow their discussion as they walk from Knossos to the Dictean cave and temple of Zeus, following the same processional path trodden by King Minos, the lawgiver of Crete on his way to receive in that holy place the laws of his land from the hands of his very father, Zeus. For them, education is one of the basic matters of any legislation. Thus, the Athenian considers that, following basic training, there are three subjects indispensable for the education of the young (817e): arithmetic, geometry and astronomy. He points out, however, the dangers inherent in the teaching of astronomy; it can lead to atheism:

> But the principles of our modern pundits do need to be denounced as a pernicious influence. Just look at the effects of their arguments! When you and I present our proofs for the existence of gods and adduce what you adduced – sun, moon, stars and earth – and argue they are gods and divine beings, the proselytes of these clever fellows will say that these things are just earth and stones, and are incapable of caring for human affairs, however much our plausible rhetoric has managed to dress them up. (886d)

In any case, Plato finds that the teaching of astronomy is socially necessary. Even if he systematically ignored the fact that four seasons are unequal in length, as discovered some 50 years before by Meton and Euktemon (Dreyer, 1953), he could not disregard the early tradition of the Greek astronomy, including Hesiod's *Works and Days* (Goldstein, & Bowen, 1983), as well as the importance of calendars for the society. Thus, his anonymous Athenian explains how astronomy can provide the means for the temporal definition of events which mark communal life in a state: "Every year after the summer solstice the entire state should congregate in a precinct dedicated jointly to Apollo and the Sun ..." (946a)

In the same spirit he states "... on the day just before the new year opens in the month after the summer solstice; ..." (767c), and

> But how will the law itself adequately convey its teaching … for the same reasons they must acquire such knowledge about the heavenly bodies in their courses – sun, moon and stars – as will help them with the arrangements that every state is forced to make in this respect. You ask what arrangements we are referring to? We mean that the days must be grouped into months, and the months into years, in such a way that the seasons, along with their various sacrifices and festivals, may each receive proper recognition by being duly observed in their natural sequence. (809b)

along with

> Now then, the next job is to … draw up a programme of festivals to be established by law ... to decide the number and the occasions, … There are to be no less than three hundred and sixty-five of them, so as to ensure that there is always at least one official sacrificing to some god … (828a)

and, finally: "… before the rising of Arcturus ushers in the vintage … " (844e)

Therefore, schools should teach Logic, Mathematics and "… the mutual relationship of the heavenly bodies as they revolve in their courses. …" (817e) since:

> A man, at any rate, will fall a long way short of such godlike standards … if he … can't reckon up the days and the nights, and is ignorant of the revolutions of the sun and moon and the other heavenly bodies. (818c)

3 PLATO'S TIMES

Plato's educational model stems from Egypt, stated also in (819b-e), where temples were the centres of learning, encompassing both primary schools, where children learned reading and writing, divine history, state organization, arithmetic, history, and geography, as well as secondary schools or technical schools where the young became sculptors, draughtsmen, or engravers serving the needs of the kingdom (Montet 1988).

This was quite contrary to Athenian practice where schools were private. Children, meaning boys only of course, were taught reading, writing, arithmetic, music and at a later age gymnastics (Flaceliere, 1971). The knowledge offered by these schools was rudimentary. Yet, the time span between the end of the Persian Wars and the defeat of Athens in the hands of Sparta was a particularly creative one for the arts and sciences and witnessed quite a few educational changes. The first such reform was brought about by the sophists, offering for a generous fee their knowledge of geometry, physics, astronomy, the arts, rhetoric, and philosophy.

At the same time, a number of wise men, among whom Anaxagoras, Zeno, and Democritus came to Athens to satisfy the demands of a public hungry for new ideas. This thirst for learning resulted in the creation of institutions of higher learning: Plato founded the Academy on the Pythagorean model in 387 BC, Aristotle the Peripatetic school, Isocrates his school of rhetoric and philosophy, advocating views contrary to those of the Academy; many smaller schools founded by less renowned teachers would follow.

This was an age characterized by intellectual self-confidence: man felt mature and ready to study nature and discover the laws that define and determine the universe.

It is worthwhile making a brief digression here: it has often been claimed that the sciences in Greece were directly derived from their counterparts in Egypt and Babylonia. It is true that the Greeks took over elements of these earlier civilizations: an example is that of reciprocals – fractions with a numerator equal to one – which formed the basis of non-integer arithmetic in Athens; these were already in use in Egypt a thousand years before the time of Pericles and in fact remained in use under the Romans and into the Middle Ages. However, before the Greeks, the sciences were characterized by their practical spirit; knowledge was oriented to specific applications, problems did not encounter a general statement, exact methods and results were confused with approximative ones. All this was in complete contradiction to the characteristics of Greek science (Boyer, 1985).

Thus, despite the multifarious intellectual searches of his time, Plato remains loyal to the theocratic, utilitarian, and static Egyptian model, according to which even music should be devoted to the gods so that any musical innovation can be considered an affront to the gods, worthy of punishment (799-800b). Moreover, the acquisition of knowledge in the authoritarian and strictly controlled society that Plato proposes (689e-690e) is not the right of every citizen: "None of these subjects must be studied in minute detail by the general public, but only by a chosen few." (818a)

4 THE ROLE OF THE SENSES IN PERCEPTION

For Plato, Knowledge is remembrance rather than sensation, to be achieved through mystical contemplation and intuition and not through the senses (Russell, 1972). The senses only lead human beings to illusions:

> ATHENIAN: My dear fellows, at the present day nearly all we Greeks do the great gods – Sun and Moon – an injustice.
> CLEINIAS: How so?
> ATHENIAN: We say that they, and certain other heavenly bodies with them, never follow the same path. Hence our name for them: 'planets'.
> CLEINIAS: Good heavens, sir, that's absolutely right. In the course of my life I've often seen with my own eyes how the Morning and the Evening Star, and a number of others, never describe the same course, but vary from one to another; and we all know that the sun and moon always move like that. (821bc)

Cleinias had already remarked that the orbit of Venus around the earth was "irregular". Moreover, irregularities are in the Platonic view synonymous with evil (897cd), see also in Boodin (1930) and Meldrum (1950). Thus, Plato's disciples, Eudoxus and, a little later Callippos, resolved the Sun's orbit, as well as the orbits of the other planets, into thirty circular "regular" motions, in accordance with the precepts of Plato (Goldstein, & Bowen, 1983; Neugebauer, 1957). Whether Plato was, or was not aware of the work by Eudoxus when he was writing *The Laws*, or, even, whether it was he who initiated and suggested this work in order to "save the phenomena", that is to show the regularity of the motions of the planets, has been the issue of many discussions that can be traced for example in Knorr (1990), Mittelstrass (1962), Mourelatos (1981), and Vlastos (1980).

The thirty regular circular motions in the analysis of Eudoxus and Calippos were inadequate for the description of the planets' orbits, but it is well known today that any periodic orbital motion – in general any variation of a closed orbit – can be satisfactorily accounted for by a – possibly infinite – sum of regular circular motions. We thus come across the first analysis of movement in the history of the sciences (Palter, 1970) that is very similar to the analysis in Fourier series; all this due to Plato's theory of the universe according to which the planets, being ideal beings, followed "perfect" circular orbits!

It is worth noting here that the theoretical model of Eudoxus was constructed by the Italian astronomer Schiaparelli, 1835-1910, (Mourelatos, 1981), which demonstrated the failure of the Eudoxean model to describe the relevant celestial motions. However, the failure of a model created 23 centuries ago does not diminish the importance of the work of Eudoxus in the evolution of astronomy.

5 SOPHISTS AND PHYSICAL PHILOSOPHERS

One of the major issues for philosophical debate influencing political life in Plato's time concerned the confrontation between law and nature fuelled by the teachings of the natural philosophers and the sophists. Plato did not directly take position in this debate (Ostwald, 1977), but his work describes clearly his ideas: the laws proposed in *The Laws* by the Athenian govern even the motion of the planets, contrary to everyday experience though this must seem:

> This belief … that the moon and sun and other heavenly bodies do in fact 'wander', is incorrect: precisely the opposite is true. Actually, each of them perpetually describes just one fixed orbit, although it is true that to all appearances its path is always changing. Further, the quickest body is wrongly supposed to be the slowest and vice versa. (822abc)

The tenth book of *The Laws* gives an explanation of Plato's theological astronomy. All those referred to below are not only wrong but also guilty of impiety before the gods:

> Some people, I believe, account for all things which have come to exist, all things which are coming into existence now, and all things which will do so in the future, by attributing them either to nature, art, or chance. (888e)

He is in fact referring to the Ionian physical philosophers, the first ones attempting an explanation of natural phenomena without recourse to metaphysical notions, a full two centuries before Plato. They are his ideological opponents, just like the sophists, critical of established ideas (Boyer, 1985). Plato goes on to refer to them in the following terms:

> The facts show – so they claim – that the greatest and finest things in the world are the products of nature and chance, the creations of art being comparatively trivial ... They maintain that fire, water, earth and air owe their existence to nature and chance, and in no case to art, and that it is by means of these entirely inanimate substances that the secondary physical bodies – the earth, sun, moon and stars – have been produced. These substances moved at random, each impelled by virtue of its own inherent properties, which depended on various suitable amalgamations of hot and cold, dry and wet, soft and hard, and all the other haphazard combinations that inevitably resulted when the opposites were mixed. This is the process to which all the heavens and everything that is in them owe their birth, and the consequent establishment of the four seasons led to the appearance of all plants and living creatures. The cause of all this, they say, was neither intelligent planning, nor a deity, nor art, but – as we've explained – nature and chance. (889cd)

And Plato explains why he fights against such ideas originating in the sophists and the physical philosophers:

> All this, my friends, is the theme of experts – as our young people regard them – who in their prose and poetry maintain that anything one can get away with by force is absolutely justified. This is why we experience outbreaks of impiety among the young, who assume that the kind of gods the law tells them to believe in do not exist; this is why we get treasonable efforts to convert people to the 'true natural life', which is essentially nothing but a life of conquest over others, not one of service to your neighbour as the law enjoins. (890a)

According to Plato, nature has no moral values and the acceptance of natural laws would damage social life (see also Ostwald, 1977; Solmsen, 1977). Furthermore, natural phenomena should exhibit ethical and aesthetical order (Goldstein, & Bowen, 1983). This is why he advises the young to turn a deaf ear to teachings purporting to modify their early, childhood beliefs about the gods, as in due time they are bound to return to them (888b). Traditionally, all are taught from an early age to believe in the gods and pray to them:

> At the rising and setting of the sun and moon the children saw and heard Greeks and foreigners, in happiness and misery alike, all prostrate at their devotions; far from supposing gods to be a myth, the worshippers believed their existence to be so sure as to be beyond suspicion. (887d)

6 THE NATURE OF THE STARS

Plato then (891c-893e) goes on to discuss the nature of stars. This analysis revolves around the role of the soul: "It is one of the *first* creations, born long before all physical things, and is the chief cause of all their alterations and transformations."(892ac)

Since "... the definition of the thing we call the soul: ... 'motion capable of moving itself' ... " (895a-896a), from the definition of what constitutes being:

> This is then the process of change and alteration to which everything owes its birth. A thing exists as such as long as it is stable, but when it changes its essential state it is completely destroyed. (894b)

Plato infers that change destroys being. This is significant: the Platonic world, contrary to that of the Ionian philosophers has no space for "becoming", only "being" (Sinachopoulos & Sinachopoulos, 1991). This destruction of being through change leads Plato to conclude:

> Well then, what kind of soul may we say has gained control of the heavens and earth and their entire cycle of movement? ... If ... the whole course and movement of the heavens and all that is in them reflect the motion and revolution and calculation of reason, and operate in a corresponding fashion, then clearly we have to admit that it is the best kind of soul that cares for the entire universe and directs it along the best path. (897c)

In the next (898c) and subsequent paragraphs, he expresses a world view in fundamental contradiction to that of the view of the natural philosophers:

> ... since we find that the entire cycle of events is to be attributed to soul, the heavens that we see revolving must necessarily be driven round ... because they are arranged and directed *either* by the best kind of soul *or* by the other sort. ...
>
> If, in principle, soul drives round the sun, moon and the other heavenly bodies, does it not impel each individually? ... Whether we find that it is by stationing itself in the sun and driving it like a chariot, or by moving it from outside, or by some other means, that this soul provides us all with light, every single one of us is bound to regard it as a god. Isn't that right? (898c)

Thus, for the first time in human history, and using an astronomical model as a tool, a 'proof' of the existence of gods is given, the worship of divinity appears in philosophy and Plato can claim to be the founder of philosophic theology (Taylor, 1978). As Zeller and Nestle (1980) explain:

> It was through Pythagoreanism that he [Plato] obtained his knowledge of two sciences which were appropriate to his idealistic system and at the same time formed a link between the world of the mind and the world of matter.

> Mathematics taught what was eternal in the earthly and perceived the supersensual in the material, while astronomy turned the gaze from the earth and directed it into the depths of the universe to those mysterious celestial bodies which move of movements are ordered by number and by measure and can be comprehended by the thinking mind. Mathematics of course was only 'a ferment in Plato's mysticism' and the star gods strictly speaking belonged to the heavenly world.

This observation makes it easier to understand Plato's assertions such as the following:

> Now consider all the stars and the moon and the years and months and all the seasons: what can we do except repeat the same story? A soul or souls – and perfectly virtuous souls at that – have been shown to be the cause of all these phenomena, and whether it is by their living presence ... we shall insist that these souls are gods. (899b)
>
> His astronomical system now completed, Plato proceeds to sum it up:
>
> Now then, ... let's delimit the courses of action open to anyone who has so far refused to believe in gods, and get rid of him ... *either* he should demonstrate to us that we're wrong to posit soul as the first cause to which everything owes its birth, and that our subsequent deductions were equally mistaken, *or*, if he can't put a better case than ours, he should let himself be persuaded by us and live the rest of his life a believer in gods. (899c)

Plato thus considers astronomy and, by extension, physics in a completely theological and metaphysical spirit, convinced that everything that exists in the world has to be "ideal", in vindication of his world view (Dreyer, 1953; Russell, 1972; Taylor, 1978). Furthermore, his disdain of perceptual experience (Lloyd, 1968) and his belief that nature, being in a state of permanent flux, is not knowable (Ostwald, 1977) lead him to the position that nature cannot be the object of science (Mittelstrass, 1962). His spirit was contrary to observation and experiment (Goldstein & Bowen, 1983), this being probably his only point of disagreement with the Pythagoreans (Vlastos, 1980; Zeller & Nestle, 1980) who had used experiment in developing the theory of harmonics.

7 EPILOGUE TO *THE LAWS*

Plato returns to astronomy in the closing paragraphs of *The Laws* (966e) to emphasize once again how dangerous the teachings of the physical philosophers are, as they lead to atheism:

> Now we know, don't we, that among the arguments we've already discussed, there are two in particular which encourage belief in the gods? ... One is the point we made about the soul, when we argued that it is far older and far more divine than all those things whose movements have sprung up and provided the impulse which has plunged it into a perpetual stream of existence. Another argument was based on the systematic motion of the heavenly bodies and the other objects under the control of reason, which is responsible for the order in the universe. (966e)
>
> No one who has contemplated all this with a careful and expert eye has in fact ever degenerated into such ungodliness as to reach the position that most people would expect him to reach. They suppose that if a man goes in for such things as astronomy and the essential associated disciplines, and sees events apparently happening by necessity rather than because they are directed by the intention of a benevolent will, he'll turn into an atheist.

> ... [Some thinkers] concluded from the evidence of their eyes that all the bodies that move across the heavens were mere collections of stone and earth and many other kinds of inanimate matter – inanimate matter which nevertheless initiated a chain of causation responsible for all the order in the universe. Such conclusions led to a variety of atheistic and unpopular doctrines taking hold of these philosophers' minds; ... (966e-967d)

One has to conclude that in *The Laws*, Plato, great thinker that his admirers may consider him to be (Boyer, 1985), not only offers nothing to further the progress of astronomy, but in fact discourages its study.

8 DISCUSSION

Plato's cosmological considerations presented in *The Laws* do not fully agree with those manifested in *Timaeus* (Plato2), see also Boodin (1930), Hackforth (1959), Meldrum (1950). *Timaeus* delineates the genesis of the world, including the creation of a world soul, the stars (considered as celestial gods), the beginning of the cosmic time, and, also, the formation of the human beings, the animals and the plants. It is a Demiourgos, a Creator, who methodically created Cosmos, soul and life, and this creation has been achieved in the best way, while a second cosmic power, Necessity, governs the material aspects of the world.

The lack of complete agreement in the concepts and principles between *The Laws*, in which the soul is the origin of motion, and *Timaeus*, with the metaphysical Creator, legitimates the discussion of whether we should consider the entire Platonic work as one coherent whole, and, consequently, of whether we should expect consistency between the various Platonic strands. It is a common practice of many Platonists, for example Vlastos (1980), to use concepts of one Platonic work in order to smooth what amounts, in their opinion, to uneven points in some other work. However, the justification of such extrapolations is questionable, since knowledge and ideas evolve with time and age; there is no indication that Plato himself intended to consolidate his work in that sense. More about the issue of consistency in the entire Platonic work can be found for example in Meldrum (1950), Ostwald (1977), and Turnbull (1980).

Some scientists feel the need to restore Plato in the history of scientific thought (see e.g. Anton, 1980). Nevertheless, Plato's work hardly needs rehabilitation: its worth does not necessarily lie in his conception of astronomy or of science in general, but in the simple, everyday way he talked about the most important issues of politics, issues that are still important and under debate in our time, and about the whole spectrum of knowledge in his time. More about the originality of his teaching regarding natural sciences can be found in (Lloyd, 1968 and Mueller, 1980). Anyhow, it would be too easy to use the advantage of our age and our contemporary view of sciences to criticize work done 2400 years earlier (Mourelatos, 1981; Sinachopoulos & Sinachopoulos, 1991). What, however, remains important, and we consider it as our duty, is to become acquainted with Platonic doctrines, to attempt to understand them in the context of his time and to form our own opinion of Plato, of the evolution of science, and, even, of scientific understanding in our times.

The political positions of Plato have not often been related to his views on natural science and astronomy. Plato was a deep political thinker - disregarding the fact that we may dislike his political convictions - and his main concern in *The Laws* –and in *The Republic* and, also, *Timaeus*, as explained in the first part of *Timaeus*, – is how to rule society in the most appropriate and effective way. Natural sciences and astronomy are important to Plato only as far as they can contribute to good government, law and order. He was not concerned with science *an sich* or with theology or astronomy (Boodin, 1929; Meldrum, 1950; Mittelstrass, 1962; Solmsen, 1977). His intentions have been clearly expounded in *The Laws*, as well as in *The*

Republic: these works deal with politics and ruling. As regards cosmogony and nature, some well-narrated myths can answer all general questions about the world (Callahan, 1977), and help the rulers govern a compliant populace.

It is a regret that some important scientists who have understood well the political aspects and conclusions of Plato's work, for example Vlastos (1977), were never perceptive enough to evaluate Platonic concepts about the natural sciences in the framework of his political principles.

Yet, we cannot blame Plato for the use made of his teachings regarding astronomy and natural sciences. Through the centuries it has been convenient to deal with astronomy in the Platonic sense (Callahan, 1977; Kalfas, 1990; Mourelatos, 1981; Mueller, 1980; Solmsen, 1977; Turnbull, 1980) either because of the lack of accurate observational means, or because of religious doctrine, or, simply, because the times were not mature enough for an astronomy directly related to what happens in the skies.

It is impressive that the old confrontation between the Platonic and Aristotelian way of thinking – simplifying: theorisation, stability, and symmetry versus experience, change, and complexity (see also Donnay, 1960) – remains alive in our time, for example Barrow (1991). This may be an additional reason to go back to the roots of the relevant debates in order to arrive at a better understanding of the evolution of the natural sciences and of the factors that influenced this evolution.

9 AFTERWORD

In the introduction of the *Almagest*, a few centuries later, Ptolemy describes astronomy as the branch of knowledge dealing with the divine and heavenly bodies, adding that this is a science concerned with the study of an eternal, immutable world. Thus Ptolemy, through his belief in the Platonic model of a static and non-evolving universe, as well as his conviction that the planets are "divine bodies", is not particularly concerned with observation, though he states the contrary, neither when he compiles his star catalogue, partially copied from that of Hipparchus, or perhaps not, see e.g. in van der Waerden (1988) and Palter (1970), nor when it comes to determining the inclination of the ecliptic, which he has probably obtained from the work of Eratosthenes (van der Waerden 1988).

Thus, three hundred years after Plato, hostility towards observation had already led to disastrous results. For example, in the fifth century AD the Alexandrian explorer - and, necessarily, with a deep astronomical knowledge - Kosmas sailed from Alexandria to the Indian Ocean - hence his surname Indicopleustis -. According to him, God created a flat and not a spherical Earth. However, Dreyer (1953) points out that "As he [Kosmas] must have reached places within ten degrees of the equator, it is very remarkable that he could be blind to the fact that the earth is a sphere."

Many centuries would have to pass before a critical view of the world became possible, permitting us to try to comprehend natural laws without any metaphysical preconceptions. As Farrington (1963) remarks, "Not till the time of Kepler did astronomy rid itself of the necessity of interpreting the behaviour of the planets in terms of the social prejudices of the Pythagoreans."

10 NOTES

1. All numbers cited are references to paragraphs in *The Laws* except (Rep 530b) which refers to Plato's *The Republic*.
2. We have intentionally avoided any mention to the *Epinomis* here, which is not considered a work of Plato (e.g. Knorr, 1990), and thus should not be appended to *The Laws*, as is sometimes done for historical reasons. The *Epinomis*, probably the work of Philip of Opundium, disciple of Plato (Zeller & Nestle 1980), is a work of particular astronomical interest, where it is claimed that Mathematics and Astronomy provide the highest form of knowledge.

3. The following table contains essentially all points in *The Laws* that are directly or indirectly of astronomical interest.

11 TABLE OF PARAGRAPHS WITH ASTRONOMICAL INTEREST IN *THE LAWS*

641c	653c	677a	714e	767c	771b	809b
818a	818c	819bcd	821bc	822abc	828a	844e
886ac	886d	887d	888b	888e	889cd	890a
890d	891c	892ac	893bc	893de	894abc	894de
895abc	895de	896abc	898c-899d	946a	960d	966e

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13 REFERENCES

Anton, J.P., 1980. Introduction. In J.P. Anton (editor), *Science and the Sciences in Plato.* EIDOS, New York, pp. ix-xv.

Barrow, J., 1991. Platonic relationships in the universe? *New Scientist*, 20 April 1991, pp. 40-43.

Boodin, J.E., 1929. Cosmology in Plato's Thought, I. *Mind*, **38**:489-505.

Boodin, J.E., 1930. Cosmology in Plato's Thought, II. *Mind*, **39**:61-78.

Boyer, C., 1985. *A History of Mathematics.* Princeton University Press, Princeton, N.J.

Bulmer-Thomas, I., 1984. Plato's Astronomy. *Classical Quarterly*, **34**:107-112.

Callahan, J., 1977. Dialectic, Myth and History in the Philosophy of Plato. In H. North (editor), *Interpretations of Plato.* Mnemosyne, Bibliotheca Classica Batava, Lugduni Batavorum E.J. Brill, pp. 64-79.

Donnay, G., 1960. Le système astronomique de Platon. *Revue Belge de Philologie et d'Histoire*, **38**: 5-29.

Dreyer, J.L.E., 1953. *A History of Astronomy from Thales to Kepler*, Revised with a Foreword by W.H. Stahl. Dover Publications, New York. First edition published in 1906.

Farrington, B., 1963. *Greek Science and its Meaning for us.* Pelican Books, London. First edition published in 1944.

Flaceliere, R., 1971. *La vie quotidienne en Grèce au siecle de Pericles.* Librairie Hachette, Paris.

Goldstein B.R. and Bowen A.C., 1983. A new view of early Greek Astronomy. *Isis*, **LXXIV**:330-340.

Hackforth R., 1959. Plato's cosmogony (Timaeus 27d ff). *Classical Quarterly*, **53**:17-22.

Kalfas, V., 1990. Criteria for the birth of a new science: The case of Greek Astronomy. In P. Nicolakopoulos (ed.), *Greek Studies in the History and Philosophy of Science*, Dordrecht, pp. 171-185.

Knorr, W.R., 1990. Plato and Eudoxus on the planetary motions. *Journal for the History of Astronomy* **21**:313-329.

Lloyd, G.E.R., 1968. Plato as a natural scientist. *Journal of Hellenic Studies*, **88**:78-92.

Meldrum, M., 1950. Plato and the αρχη κακων. *Journal of Hellenic Studies*, **LXX**:65-74.

Mittelstrass, J., 1962. Die Rettung der Phaenomene, *Ursprung und Geschichte eines antiken Forschungsprinzips.* Walter de Gruyer and Co., Berlin.

Montet, P., 1988. *La vie quotidienne en Egypte au temps de Ramses.* Librairie Hachette, Paris.

Mourelatos, A.P.D., 1980. Plato's "Real Astronomy": Republic VII 527D-531D. In J.P. Anton (ed.), *Science and the Sciences in Plato.* EIDOS, New York, pp. 33-74.

Mourelatos, A.P.D., 1981. Astronomy and Kinematics in Plato's Project of Rationalist Explanation. *Studies in History and Philosophy of Science*, **12**:1-32.

Mueller, J, 1980. Ascending to problems: Astronomy and harmonics in Republic VII. In J.P. Anton (ed.), *Science and the Sciences in Plato.* EIDOS, New York, pp. 103-121.

Neugebauer, O., 1957. *The Exact Sciences in Antiquity.* Providence, Brown University Press. First edition published in 1952.

Ostwald, M., 1977. Plato on Law and Nature. In H. North (ed.), *Interpretations of Plato.* Mnemosyne, Bibliotheca Classica Batava, Lugduni Batavorum E.J. Brill, pp. 41-63.

Palter, R., 1970. An approach to the history of early astronomy. *Studies in History and Philosophy of Science*, **1**:93-132.
Plato1. *The Republic*. Translated with an introduction by Desmond Lee. Penguin Classics London, 1987. First edition 1955.
Plato2. *Timaios*. Translated with an introduction by Kalfas Vasilis. Polis, Athens (in Greek), 1995. (ISBN: 960-7478-11-8)
Plato3. *The Laws*. Translated with an introduction by Trevor Saunders. Penguin Classics, Harmondsworth, Middlesex, 1970.
Russell, B., 1972. *A History of Western Philosophy*. Simon and Schuster, New York. First edition in 1946.
Sinachopoulos, A. and Sinachopoulos, D., 1991. The Teaching of Astronomy in Plato's Republic. *The Astronomy Quarterly*, **8**:181-187.
Solmsen, F., 1977. Plato and Science. In H. North (ed.), *Interpretations of Plato*. Mnemosyne, Bibliotheca Classica Batava, Lugduni Batavorum E.J. Brill, pp. 86-105.
Taylor, A.E., 1978. *Plato, The Man and his Work*. Methuen and Co. Ltd., London. First edition in 1926.
Turnbull, R.G., 1980. The later platonic concept of scientific explanation. In J.P. Anton (ed.), *Science and the Sciences in Plato*. EIDOS, New York, pp. 75-101.
van der Waerden, B.L., 1988. *Die Astronomie der Griechen, Eine Einfürung*. Darmstadt, Wissentschaftliche Buchgesellschaft.
Vlastos, G., 1977. The theory of social justice in the *Polis* in Plato's Republic. In H. North (ed.), *Interpretations of Plato*. Mnemosyne, Bibliotheca Classica Batava, Lugduni Batavorum E.J. Brill, pp. 1-40.
Vlastos, G., 1980. The role of observation in Plato's conception of astronomy. In J.P. Anton (ed.), *Science and the Sciences in Plato*. EIDOS, New York, pp. 1-31.
Zeller, E. and Nestle, W., 1980. *Outlines of the History of Greek Philosophy*. New York, Dover. First edition of the original the work by Zeller in 1883.

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Airy and the survey of the Maine–New Brunswick boundary (1843-1845)

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Abstract
Sir G B Airy, the astute Astronomer Royal of the mid-nineteenth century, left an extensive accumulation of archival documents, now housed at Cambridge University in the UK. A small collection of Airy papers, dealing specifically with the Maine-New Brunswick boundary survey of the 1840s, is held by the National Archives of Canada at Ottawa, Canada. An outline of Airy's involvement in this combined astronomy-surveying project is presented in this paper.

Key Words: *Airy, surveying, instructions*

At the time of the closing of Herstmonceux about 1990, the Airy Papers held in the Archives of the Royal Greenwich Observatory (RGO) were transferred to the Archives at Cambridge University, Cambridge, UK. As Airy is reported to have saved every scrap of paper he generated during his lengthy term as Astronomer Royal from 1835 to 1881, this is a very extensive collection. Another small, unique, and important holding of Airy papers is housed in the National Archives of Canada (NAC), Ottawa, Canada. These documents contain the details associated with the Maine-New Brunswick Boundary survey of 1843-1845, an operation in which Airy became the dominant scientist in planning and conducting this major undertaking.

How did the Astronomer Royal, Sir George Biddell Airy, become so involved in a boundary survey? Early in January 1843, the Foreign Office wrote to Airy to see whether he might recommend one or two practical astronomers qualified to undertake the astronomical work connected with running and tracing certain parts of the boundary between the British Dominions in North America and the United States. Following the Revolutionary War, the 1783 treaty delineated the north-east boundary between the two countries as the middle of the St. Croix River to its source, then due north to certain highlands and along them "... to the north-westernmost head of the Connecticut river", Figure 1. Although the southern portion of this boundary was settled, it was not until 1831 that an arbitrator, William I, King of the Netherlands, gave a decision which did not please Maine. The Aroostook War of 1838-1839 was over the boundary; however, General Winfield Scott negotiated a truce and three years later this specific project arose from the terms laid down in the Webster-Ashburton Treaty, signed by the two countries in 1842. In his reply Airy suggested that Officers of the Royal Engineers might be employed for this work, an arrangement which eventually materialized. He also asked the Foreign Office for clarification of certain parts of the Treaty. Within a month, Airy had projected himself into the very heart of the project.

There are seventy-five hand-written pages of "Instructions to Officers Acting as Prinicipal Astronomers for Defining the Boundary Line in North America" in the Airy collection at NAC. These instructions are divided into twelve sections, each dealing with a specific method to be followed in field observations. Was Airy well acquainted with the principles of nineteenth century surveying and capable of drafting such guidelines? When this question was raised with Dr Allan Chapman at Oxford University as to whether Airy "... had more than a casual acquaintance with practical Surveying?" his reply was stated clearly:

> At no stage in his life did Airy do any sustained astronomical observation, let alone surveying. Where he gained his intimate familiarity with practical surveying and geodesy, is something of a mystery about which none of his surviving papers speak. I strongly suspect, however, that Airy may never have had such experience or training ... (Chapman 1989).

And so this mystery of Airy's expertise in field surveying remains with us. How well did his "Instructions" permit the field parties to carry out their assignments? He writes:

> You remember that I instructed Capt. Robinson & M^{r} Pipon to get the absolute Latitudes and the difference of Longitude of the two ends of the long line (70 miles), then to compute the azimuths, and, laying down marks for these completed azimuths, to cut roadways in straight lines.
>
> This they did, and began simultaneously at both ends to cut through the woods. (Airy 1844).

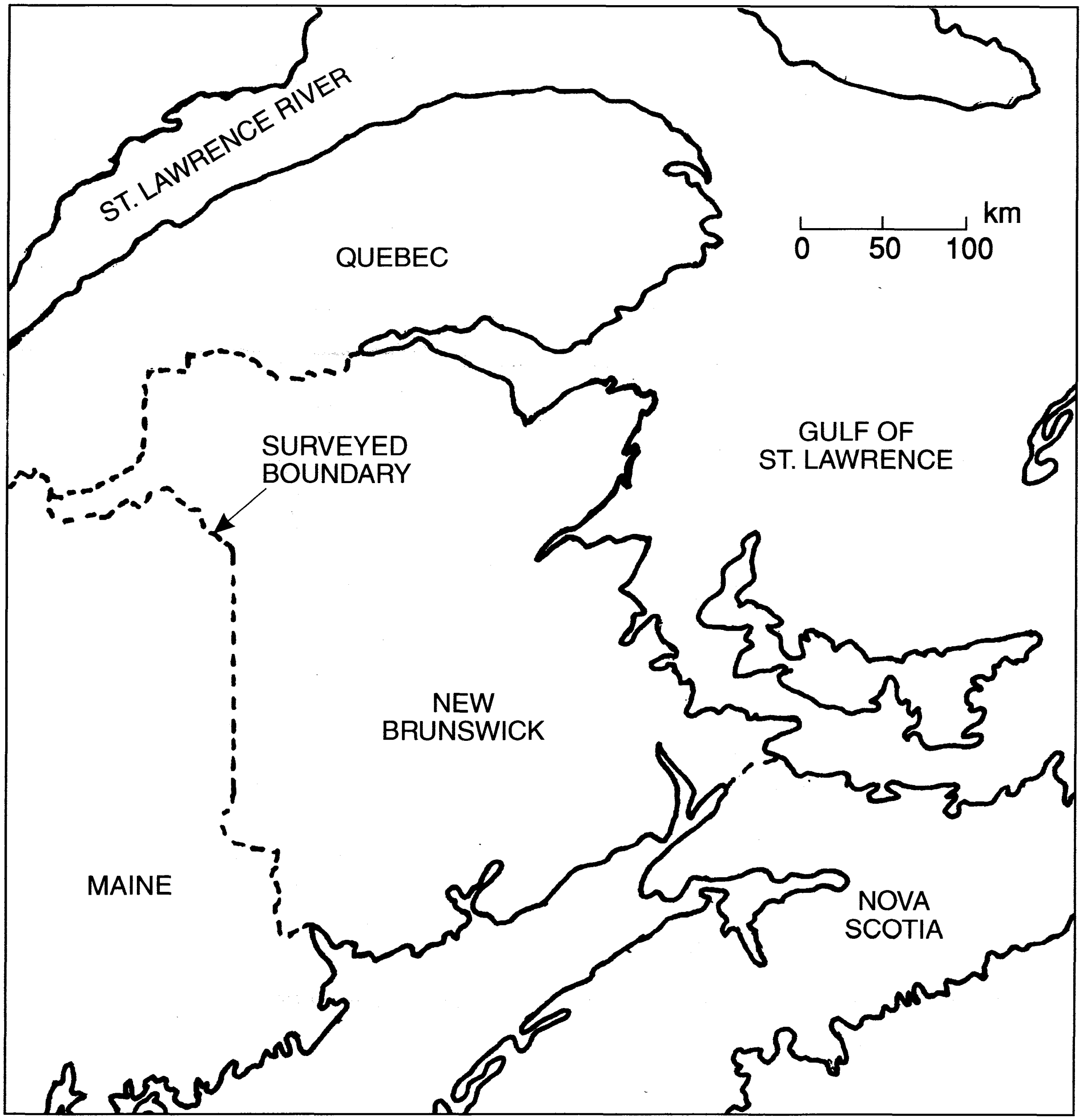


Figure 1. The dashed-line shows the boundaries of New Brunswick with Maine and Quebec. The disputed portion surveyed by the Officers of the Royal Engineers is indicated.

Colonel Estcourt's account is as follows:

> On the 17th of April, about 4 PM, Mr Scott (who conducted the stronger party and had cut 42½ miles) from the top of a tree saw an opening begin to appear in the ridge just before him. It increased, and was soon made out to be the head of Mr Pipon's line : it was his cutting party, and apparently directly in line. Upon prolonging the lines until they were abreast of each other, the whole distance between them proved to be 341 feet. (ibid.)

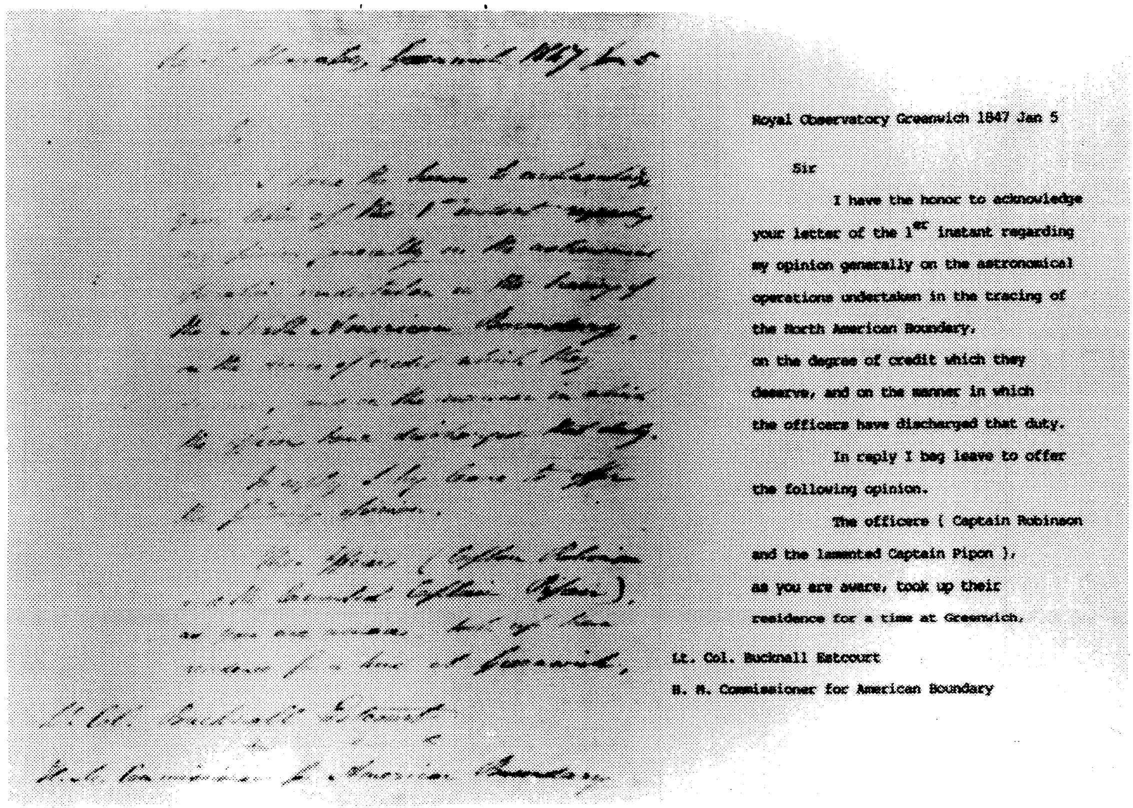
To this success Airy remarked: "This is one of the best operations of its kind that I ever knew." (ibid.) It may well have been the only such operation known to the Astronomer Royal!

When did this small collection of Airy papers reach Canada? In 1898, Otto J Klotz visited Greenwich in search of documents relevant to the settlement of the Alaskan Boundary dispute (Order-in-Council, 1898).[1] While it must be admitted that the Maine-New Brunswick boundary was far removed from Alaska, Klotz somehow persuaded the Astronomer Royal to have these Airy papers transferred to Ottawa, which in turn involved approval by the Admiralty, the Colonial Office, and the Office of the High Commissioner for Canada. These papers did not reach the Public Archives of Canada, now NAC, until 1934. With so much time spent in an environment without controlled temperature and humidity, the Airy papers suffered serious deterioration, consisting of embrittling of the pages, fading and migration of the ink. When the collection was examined at Ottawa in the early 1980s, it was quite apparent that immediate steps should be taken to preserve the essential parts, namely Airy's "Instructions to Officers", the "Correspondence", and "Supplementary Correspondence" connected with the 1843-1845 boundary survey.

In 1984, mainly owing to financial considerations, the only process readily available for the preservation of these documents was the preparation of typescript copies. NAC provided the University of Saskatchewan with photocopies of the Airy papers cited above and agreed to copy the typescripts on acid-free paper for long-term preservation. The deciphering of Airy's handwriting, coupled with the quality of the photocopies, made progress slow and the project time-consuming. With the assistance of the University of Saskatchewan Archivist, the monthly completion amounted to about twenty pages of satisfactory typescript. Over a period of nearly three years, the seventy-five pages of the "Instructions to Officers", along with nearly six hundred pages of "Correspondence" (Figure 2) and "Supplementary Correspondence", have been preserved using this approach.

Among other items in the Airy collection at NAC are thirty field books, volumes (on which the Greenwich shelf numbers are still retained) of reductions by Airy of the field observations, star transit observations by the two Royal Engineers – Robinson and Pipon – checking of chronometer rates and transport of these for the determination of longitude differences and observations with Altitude-Azimuth instruments for latitude determinations. While these documents, for the benefit of historians of science, might be preserved by microfilming before further deterioration occurs, the demand for and availability of these services at NAC has delayed the implementation of this programme. A substantial portion of this important Airy collection may not be preserved for future study.

In retrospect, Airy's "Instructions to Officers" covered all the basic procedures for the field survey of the boundary in 1843-1845, such as adjusting a Transit instrument, the proper use of an Altitude-Azimuth instrument for determining the latitude, checking the rates, and keeping warm the chronometers which were used in the survey. Few of these procedures would be utilized in carrying out a field survey in the latter part of the twentieth century. In little more than 150 years the advances in technology have been so rapid that the mid-nineteenth century procedures outlined by



Royal Observatory Greenwich 1847 Jan 5

Sir

I have the honor to acknowledge your letter of the 1st instant regarding my opinion generally on the astronomical operations undertaken in the tracing of the North American Boundary, on the degree of credit which they deserve, and on the manner in which the officers have discharged that duty.

In reply I beg leave to offer the following opinion.

The officers (Captain Robinson and the lamented Captain Pipon), as you are aware, took up their residence for a time at Greenwich.

Lt. Col. Bucknall Estcourt
H. M. Commissioner for American Boundary

Figure 2. A composite of a page of the photocopies supplied by NAC of a letter from Airy to Lt.-Col. Bucknall Estcourt and the typescript prepared from this letter. The quality of the photocopy, coupled with Airy's handwriting, made the preparation of typescript a lengthy and painstaking process.

Airy may soon be forgotten. When our attention is turned to the Global Positioning System (GPS), along with permission to use the most precise code available from the related satellites circling above Earth, the field surveyors now have at their disposal the ability to fix locations on Earth's surface with an accuracy far superior to the best work which could have possibly been obtained by the Royal Engineers in 1843-1845.

Airy's contributions to the Maine-New Brunswick Boundary survey remain as one of his many important achievements as Astronomer Royal. He was among the top-ranking British scientists of the middle and later part of the nineteenth century. Not only did he dominate development in all phases of astronomy in Britain, he also played a major part in the progress of science in closely related fields (see Airy 1896). At the same time he sensed the need to communicate information on astronomy to people in all walks of life; his Ipswich Lectures (Airy 1849) remain a clear testimony to his ability to carry this venture through successfully, as well as to implore other scientists to do likewise.

Reporting to the Board of Visitors of the Greenwich Observatory in 1844, Airy stated that the survey work on the Maine-New Brunswick Boundary had been achieved by a party of British Officers working in accordance with a plan devised by the Astronomer Royal. Never an individual to fail to remind the politicians of the day about the Royal Observatory, Airy remarked : "I think that I may here assume that the aid of this institution has been beneficial to another department of state." (Chapman 1989). Unquestionably a very astute Astronomer Royal, time and again during his long and illustrious career at Greenwich, Airy took full advantage of this golden opportunity to influence the Foreign Office in carrying out the Maine-New Brunswick Boundary survey of 1843-1845.

While the Archives of the RGO were still at Herstmonceux, a gift was made to them of the typescript of the Airy "Instructions to Officers". After the Archives were moved to Cambridge, the Archivist purchased from the University of Saskatchewan Archives, typescript copies of Airy's "Correspondence" and "Supplementary Correspondence" associated with this Boundary survey. While this portion of the NAC collection has been preserved adequately for historians of science in both Canada and the United Kingdom, concern remains over the potential loss of some important sections of Airy's contributions to field surveying in the mid-nineteenth century.

ACKNOWLEDGEMENTS

The assistance of S D Hanson, University Archives, University of Saskatchewan, in deciphering Airy's handwriting and in assembling the reference Notes appended to this paper, is gratefully acknowledged herewith.

NOTES

1. This Order-in-Council, quoted in part below, stated that W.F. King (Note 8), Commissioner under the International Commission of 1892, was to be sent to Europe "... to search for maps and documents relating to the boundary between Canada and the United States ..." With a meeting of the International Commission scheduled to be held in Quebec in August of that year to consider the Alaskan boundary question, the Minister of the Interior was of the opinion that it conversant with the main points of the Canadian contention ... be sent to Europe in place of Mr. King." Klotz was a member of a group of scientists responsible for planning the Dominion Observatory at Ottawa and became its second director in 1917. As a surveyor, Klotz was involved in establishing positions for the Canadian Pacific Railway right-of-way through British Columbia in 1885, and in the determination of the longitude of Montreal with respect to Greenwich. W.F. King, referred to above, was responsible for the formation of the astronomical branch of the Department of the Interior, and later became the first director of the Dominion Observatory in Ottawa.

BIBLIOGRAPHY

Airy, G.B., 1844. Letter to Colonel Colby, dated 4 June. In the "Supplementary Correspondence" held in the University of Saskatchewan Archives (MG 102 – J.E. Kennedy Fonds).

Airy, G.B., 1849. *Six Lectures on Astronomy Delivered at the Meetings of the Friends of the Ipswich Museum. at the Temperance Hall, Ipswich, in the month of March, 1848.* (*NUC Pre-1956 Imprints*, Vol. 6, page 72).

Airy ,W. (ed.), 1896. *Autobiography of Sir George Biddell Airy, K.C.B.* Cambridge University Press, Cambridge.

Chapman, A., 1989. Letter to J.E. Kennedy, dated 4 November,

Order-in-Council P.C. No. 1638 of June 1898.

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Halley as an eclipse pioneer: his maps and observations of the total solar eclipses of 1715 and 1724

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Abstract
Total solar eclipses crossed England in 1715 and 1724, and Edmond Halley took advantage of the occasions to make broadside maps in order to solicit observations and to summarize the results. His articles in *Philosophical Transactions of the Royal Society* turn out to represent early references to phenomena usually associated with later observers. This article describes reports and maps by Halley and by other scientists of the time, including William Whiston. The Houghton Library of Harvard University and the Royal Astronomical Society of London, between them, own copies of all these maps. The maps drawn by Halley and Whiston for the 1724 eclipse are surprisingly similar to a modern map drawn for the 1999 August 11 total solar eclipse.

Key words: *solar eclipses, Edmond Halley, maps, history, England*

1 INTRODUCTION

Though principally associated in the public mind with comets (Olson and Pasachoff, 1997), Halley was a polymath with major discoveries in a variety of fields, as described in a major new biography (Cook, 1998). His observations and observations of others that he solicited for the 1715 and 1724 total solar eclipses are still valuable for studies of possible secular changes in size of the Sun, a topic with implications for global warming.

In 1715, ten years after his seminal work on comets, Halley drew a map showing the predicted path of a total solar eclipse. Gingerich (1992) has written that this 1715 map was the first to show the view from above the path of a total eclipse (see also Pasachoff, 1999). Armitage (1997) describes how Halley's maps were a substantial improvement on the crude maps shown earlier that appeared as part of larger maps, and also shows William Whiston's graphical predictions of the same eclipse, which do not show the comparison with a map showing the geography. (Whiston was Newton's successor as Lucasian Professor at Cambridge University.) Armitage also describes a map of this eclipse by Joseph Crosthwait, an assistant of Flamsteed. Dopplemayr (1742) shows two views from above of the path of the 1706 eclipse that crossed Europe, but the date at which these maps were drawn is not clear.

The Houghton Library of rare books at Harvard University has four versions of Halley eclipse maps. The library of the Royal Astronomical Society in London has three of the four maps as well as another map of the 1724 path by William Whiston, a rival of Halley. These maps are broadsides, printed on one side of single sheets of paper. Broadsides survive less often than printed books, since they were not as obviously worthy of preservation. Roberta J M Olson, an art historian, and I (Olson and Pasachoff, 1989) have discussed German broadsides from the two centuries before Halley's, and their use for describing comets.

2 THE PREDICTIONS OF 1715

Halley's first map (Figure 1) is headed: "A Description of the Passage of the Shadow of the Moon over England, In the Total Eclipse of the Sun, on the 22^{d} Day of April 1715 in the Morning."

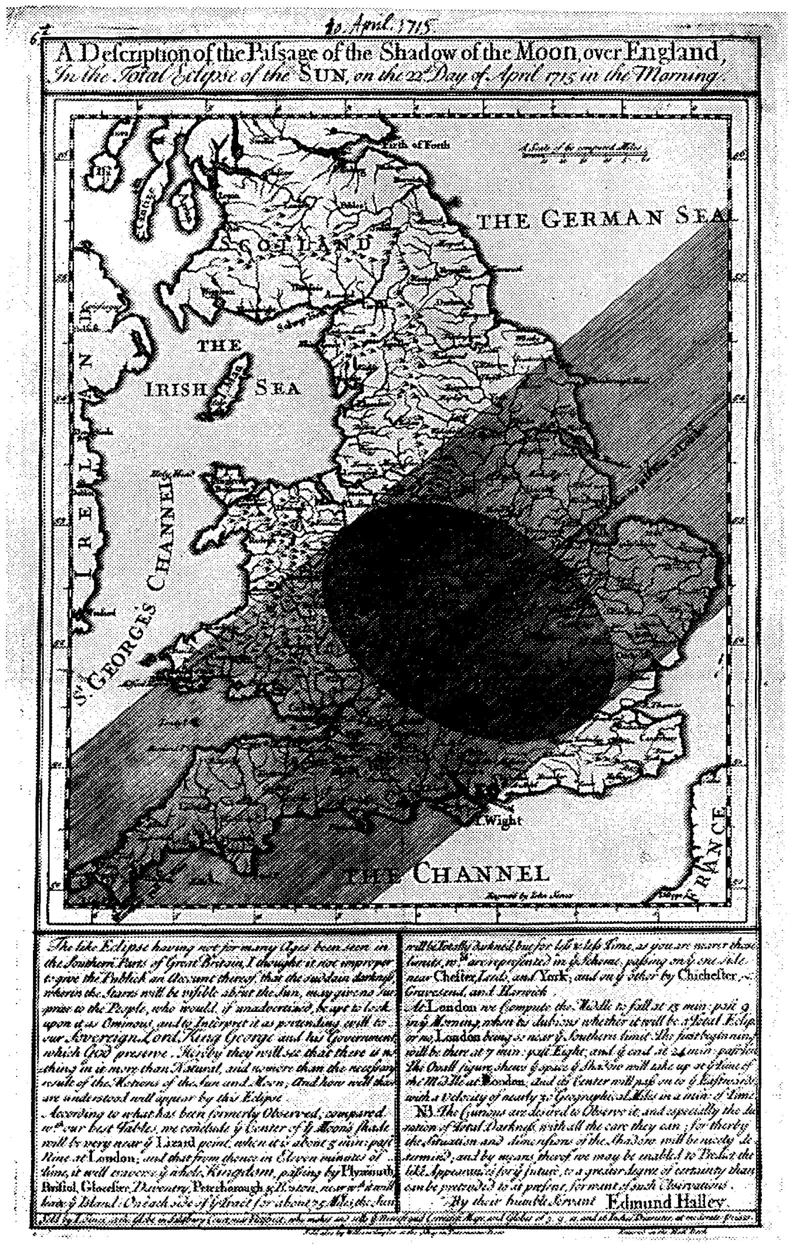

Figure 1. Drawn before the 22 April 1715 total eclipse, the figure shows Halley's predicted path of totality. (With the permission of the Houghton Library, Harvard University. EB7 H1552 715d)

Halley shows the oval shape of totality at a given instant, while also showing the path which that oval traces out. Text below the map describes:

> The like Eclipse having not for many Ages been seen in the Southern Parts of Great Britain, I thought it not improper to give the Publick an Account thereof, that the suddain darkness, wherin the Starrs will be visible about the Sun, may give no surprize to the People, who would, if unadvertized, be apt to look upon it as Ominous, and to Interpret it as portending evill to our Sovereign Lord King George and his Government, which God preserve. Hereby they will see that there is nothing in it more than Natural, and nomore than the necessary result of the Motions of the Sun and Moon; And how well those are understood will appear by this Eclipse.

According to what has been formerly Observed, compared w^th^ our best Tables, we conclude y^e^ Center of y^e^ Moon's shade will be very near y^e^ *Lizard* point, when it is about 5 min:past Nine at *London*; and that from thence in Eleven minutes of Time, it will traverse y^e^ whole Kingdom, passing by *Plymouth, Bristol, Glocester,* Daventry, *Peterborough,* & Boston, near which it will leave y^e^ Island: On each side of y^e^ Tract for about 75 Miles, the Sun will be Totally darkned; but for less & less Time, as you are nearer those limits, w^ch^ are represented in y^e^ Scheme, passing on y^e^ one side near *Chester,* Leeds, and *York*; and on y^e^ other by *Chichester,* Gravesend, and Harwich.

At *London* we Compute the Middle to fall at 13 min: past 9 in y^e^ Morning, when 'tis dubious whether it will be a Total Eclipse or no, *London* being so near y^e^ Southern limit. The first beginning will be there at 7 min: past Eight, and y^e^ end at 24 min: past Ten. The Ovall figure shews y^e^ space y^e^ Shadow will take up at y^e^ Time of the Middle at *London*; And its Center will pass on to y^e^ Eastwards, with a Velocity of nearly 30 Geographical Miles in a min: of Time.

NB The Curious are desired to Observe it, and especially the duration of Total Darkness, with all the care they can; for therby the Situation and dimensions of the Shadow will be nicely determin'd; and by means therof, we may be enabled to Predict the like Appearances for y^e^ future, to a greater degree of certainty than can be pretended to at present, for want of such Observations.

By their humble Servant *Edmund Halley*

The map was engraved and sold by John Senex, whose role as an intermediary between astronomers of that day is described by Armitage (1997). Senex is not only credited at the bottom of the map but also provides purchasing information: "Sold by J. Senex, at the Globe in Salisbury Court, near Fleetstreet; who makes, and sells ye Newest and Correctest Maps, and Globes of 3, 9, 12, and 16 Inches Diameter, at moderate Prises. Sold also by William Taylor at the Ship in Paternoster Row.Entered in the Hall Book."

The Houghton copy of this map is dated 10.April.1715 and priced at sixpence in a contemporary handwriting, reported by Gingerich (1992:154) to be that of Narcissus Luttrell, an 18th-century collector of ephemera. In Golub and Pasachoff (1997:26), we reproduced the Royal Astronomical Society print of this map.

3 HALLEY'S POST-ECLIPSE DESCRIPTIONS

Halley's first article in the *Philosophical Transactions* for later in 1715 (Halley, 1715a) was entitled "*Observations of the late* Total Eclipse *of the* Sun *on the* 22d *of* April *last past … With an Account of what has been communicated from abroad concerning the same*." (See Figure 2.) He wrote,

> Though it be certain from the Principles of Astronomy, that there happens necessarily a Central Eclipse of the Sun in some part or other of the Terraqueous Globe, about Twenty Eight times in each Period of Eighteen Years; and that of these no less than Eight do pass over the Parallel of London … it has so happened that since the 20th of March, Anno Christi 1140, I cannot find that there has been such a thing as a Total Eclipse of the Sun seen at London, though in the mean time the Shade of the Moon has often past over other Parts of Great Britain.

(Williams, 1996, has provided calculations on maps for all such eclipses from the year AD 1 to the present.)

Halley describes his reasoning in printing his map:

> The Novelty of the thing being likely to excite a general Curiosity, and having found, by comparing what had been formerly observed of Solar Eclipses, that the whole Shadow would fall upon England, I thought it a very proper opportunity to get the Dimensions of the Shade ascertained by Observation; and accordingly I caused a small Map of England, describing the Track and Bounds thereof, to be dispersed all over the Kingdom, with a Request to the Curious to observe what they could about it, but more especially to note the Time of Continuance of total Darkness, as requiring no other Instrument than a Pendulum Clock with which most Persons are furnish'd, and as being determinable with the utmost Exactness, by reason of the momentaneous Occultation and Emersion of the luminous Edge of the Sun, whose least part makes Day.

III. *Obſervations of the late* Total Eclipſe *of the* Sun *on the* 22d *of* April *laſt paſt, made before the* Royal Society *at their Houſe in* Crane-Court *in* Fleet-ſtreet, London. *By Dr.* Edmund Halley, *Reg. Soc. Secr. With an Account of what has been communicated from abroad concerning the ſame.*

THough it be certain from the Principles of Aſtronomy, that there happens neceſſarily a Central Eclipſe of the Sun in ſome part or other of the Terraqueous Globe, about Twenty Eight times in each Period of Eighteen Years; and that of theſe no leſs than Eight do paſs over the Parallel of *London*, Three of which Eight are Total with continuance: yet, from the great Variety of the Elements whereof the *Calculus* of Eclipſes conſiſts, it has ſo happened that ſince the 20*th* of *March*, *Anno Chriſti* 1140, I cannot find that there has been ſuch a thing as a Total Eclipſe of the Sun ſeen at *London*, though in the mean time the Shade of the Moon has often paſt over other Parts of *Great Britain*.

The Novelty of the thing being likely to excite a general Curioſity, and having found, by comparing what had been formerly obſerved of Solar Eclipſes, that the whole Shadow would fall upon *England*, I thought it a very proper Opportunity to get the Dimenſions of the Shade aſcertained by Obſervation; and accordingly I cauſed a ſmall Map of *England*, deſcribing the Track and Bounds thereof, to be diſperſed all over the Kingdom, with a Requeſt to the Curious to obſerve what they

could

Figure 2. From Halley's article in the *Philosophical Transactions of the Royal Society* (1715a).

Halley continues with a check on his predictions. Note that it is still 43 years before the return, as he predicted ten years before this eclipse paper, of the comet that now bears his name, so it was very valuable to him to have some satisfactory report on the results of his astronomical calculations.

> ... for the Heavens having proved generally favourable, we have received from so many Places so good Accounts, that they fully answer all our Expectations, and are sufficient to establish several of the Elements of the Calculus of Eclipses, so as for the future we may more securely rely on our Predictions; though it must be granted, that in this our Astronomy has lost no Credit.

Halley's own observations could not have better matched his predictions:

> Having computed that the Eclipse would begin at 8h.7', I attended soon after Eight with a very good Telescope of about Six Foot, without stirring my Eye from that part of the Sun whereat the Eclipse was to begin: and at 8h.6'.20". by the Clock, I began to perceive a small Depression made in the Sun's Western Limb, which immediately became more conspicuous; so that I concluded the just Beginning not to have been above five Seconds sooner; that is, exactly at 8^h.6'00" correct Time.

Just as photographs today do not do justice to the overall feeling of being outdoors during the atmospheric changes during an eclipse, Halley noticed the importance of the colours: "From this time the Eclipse advanced, ... when the Face and Colour of the Sky began to change from perfect serene azure blew, to a more dusky livid Colour having an eye of Purple intermixt, and grew darker and darker till the total Immersion of Sun, which hapened [sic] at 9^h.9'.17". by the Clock, or 9^h.9'.3". true time."
Halley wrote,

> This Moment was determinable with great nicety, the Sun's light being extinguish'd at once; and yet more so was that of the Emersion, for the Sun came out in an Instant with so much Lustre that it surprized the Beholders, and in a Moment restored the Day ... And as near as I could estimate the Points on the Moon's Limb: where the last Particle of the Sun vanished was about the middle of the South East Quadrant of her Limb, or about 45 Degrees from her Nadir to the Left-Hand: And the first Emersion was about Ten Degrees below the Horizontal Line through the Moon's Center on the West side ...

Halley's comments seem to mark the discovery of what we now know as Baily's beads, here described as "Points on the Moon's Limb"; the first mention of these Baily's beads is generally thought to be later in time (Jones and Boyd, 1971:24; quoted in Golub and Pasachoff, 1997; credit it to Samuel Williams of Harvard, who observed the eclipse from behind the enemy – British – lines at the American eclipse of 1780). Meadows (1970), in his definitive history of solar physics, states that at an annular eclipse in the 1830's, Francis Baily observed " a string of bright points along the limb of the Moon ... This phenomenon, which he attributed to the effect of sunlight shining between lunar mountains is usually referred to as Baily's beads. Although it had been observed before, the earlier accounts had been generally forgotten ..." Such beads were quite visible at the 1999 February 16 99% annular eclipse, as observed from Greenough, Western Australia.

The "last Particle of the Sun" corresponds to what we now call the Diamond Ring effect, first apparently named in 1925. Morris (1999) cites the *The Globe* (Toronto) for January 26, 1925, as reporting:

> ... said Dr. Russell. 'We astronomers were at fault in failing to emphasize more strongly that the spectator should use his naked eye for seeing the eclipse at totality and a second or so before and after' ... the light comes from a very small point, but the eye exaggerates it into a ball of light. This was spontaneously called 'the diamond ring' by numbers of observers in New York, and this term, hitherto unknown by astronomers, was apparently fixed forever as a technical term in the literature of the subject by Saturday night. 'It is a beautiful and perfect description of the effect,' said Dr. Russell.

The New York Times for January 25, 1925, uses a headline stating "Awed by Jewel of Light Hanging from Luminous Ring," and describes "A thin, luminous ring, set with a great gem of soft-burning light, hung in the eastern sky yesterday morning ... For several seconds the jewel sparkled with a pure and mild radiance, then trembled and melted into the circle of the light which rimmed the inky disk of the moon. The total eclipse had come ... The ring, with its gorgeous solitaire ..." But *The New York Times* did not explicitly use the term "diamond ring."

Halley did not know that the Moon has essentially no atmosphere.

> ... my Eye could not endure the Splendour of the emerging Beams in the Telescope from the first Moment. To this perhaps two Causes concurred; the one, that the Pupil of the Eye did necessarily dilate it self during the Darkness, which before had been much contracted by looking on the Sun. The other, that the Eastern parts of the Moon, having been heated with a Day near as long as Thirty of ours, could not fail of having that part of its Atmosphere replete with Vapours, raised by the so long continued action by the Sun; and by consequence it was more dense near the Moons [sic] Surface, and more capable of obstructing the Lustre of the Sun's Beams. Whereas at the same time the Western Edge of the Moon had suffered as long a Night, during which there might fall in Dews all the Vapours that were raised in the preceeding long Day; and for that reason, that part of its Atmosphere might be seen much more pure and transparent. But from whatever cause it proceeded, the thing it self was very manifest and noted by every one."

Would that we could show Halley the videos from the Apollo moon-landings of 1969-1972, showing the dark, airless sky of the Moon. Halley figured out the cause of the Baily's beads:

> About two Minutes before the Total Immersion, the remaining part of the Sun was reduced to a very fine Horn, whose Extremities seemed to lose their Acuteness, and to become round like Stars. And for the Space of about a Quarter of a Minute, a small Piece of the Southern Horn of the Eclipse seemed to be cut off from the rest by a good interval ...: which Appearance could proceed from no other Cause but the Inequalities of the Moon's Surface, there being some elevated parts thereof near the Moon's Southern Pole, by whose Interposition part of that exceedingly fine Filament of Light was intercepted.

Nowadays, we often describe the corona as being "pearly white" in colour. Perhaps that description originated here, with Halley:

> A few Seconds before the Sun was all hid, there discovered it self round the Moon a luminous Ring, about a Digit or perhaps a tenth Part of the Moons [sic] Diameter in Breadth. It was of a pale whiteness or rather Pearl colour. seeming to me a little tinged with the Colours of the Iris, and to be concentrick with the Moon, whence I concluded it the Moon's Atmosphere.

So Halley gave reasons for his wrong conclusion about the Moon's atmosphere, even while going on to show that his instincts were correct and that his scientific caution was admirable:

> But the great height thereof far exceeding that of our Earth's Atmosphere; and the Observations of some, who found the Breadth of the Ring to encrease on the West Side of the Moon, as the Emersion approached; together with the contrary Sentiments of those whose Judgment I shall always revere, makes me less confident, especially in a Matter whereto, I must confess, I gave not all the Attention requisite.

Halley's description of the corona remains a good one, even for our times.

> Whatever it was, this Ring appeared much brighter and whiter near the Body of the Moon than at a Distance from it; and its outward Circumference, which was ill defined, seemed terminated only by the extream Rarity of the Matter it was composed of; and in all Respects resembled the Appearance of an enlightned Atmosphere viewed from far: but whether it belonged to the Sun or Moon I shall not at present undertake to decide.

Halley went on to describe what we now call the solar chromosphere, though following a mention of flashes of light that have no current context:

> ... I found that there were perpetual Flashes or Coruscations of Light, which seemed for a Moment to dart out from behind the Moon, now here, now there, on all Sides ... And about two or three Seconds before it [the Emersion], on the same Western Side where the Sun was just coming out, a long and very narrow Streak of a dusky but strong Red Light seemed to colour the dark Edge of the Moon; tho' nothing like it had been seen immediately after the Immersion. But this instantly vanished upon the first Appearance of the Sun, as did also the aforesaid luminous Ring.

I have often commented how the appearance of the horizon during a total eclipse looks like a 360 degree sunset, and I see that I was anticipated by Halley, who wrote, "... the under Parts of the Hemisphere, especially in the South East, under the Sun, had a crepuscular brightness: and all round us, so much of the Segment of our Atmosphere as was above the Horizon and was without the Cone of the Moon's Shadow, was more or less enlightened by the Sun's Beams ..." Perhaps Halley felt competition with the Astronomer Royal, a position he was in the future to assume, for he wrote, after describing another person's observations, "The near Agreement of this Observation with our own (the Difference being only what is due to the Difference of our Meridians) makes us the less solicitous for what was noted at the Royal Observatory at Greenwich, from whence we can only learn that the Duration of Total Darkness was 3'.11"." Neither was Halley too kind, accurate as his statements may have been, to his colleagues at Oxford and Cambridge:

> Our Professors of Astronomy in both Universities were not so fortunate: My worthy Collegue Dr. John Keill by reason of Clouds saw nothing distinctly at Oxford but the End, which he observed at $10^{h}.15'.10''$. As to the total Darkness, he could only estimate it by the sudden Change of the Light of the Sky; and reckoned its Continuance but 3'.30"; which was certainly too little, the Center of the Shadow having without doubt past very near Oxford. And the Reverend Mr. Roger Cotes at Cambridge had the misfortune to be opprest by too much Company, so that, though the Heavens were very favourable, yet he miss'd both the time of the Beginning of the Eclipse and that of total Darkness."

Halley sent a message to us for this summer's eclipse:

As for the Limits of the Shade, both on the North and South side, we have by Enquiry gotten them with all the Exactness the thing is capable of, and we should have been glad the French Astronomers had done the like for the Total Eclipse that past over Languedoc, Provence and Dauphiny on the First of May 1706. But as this is the first Eclipse of this kind that has been observed with the Attention the Dignity of the Phænomenon requires, we hope those which may happen for the future to traverse Europe, may not pass by so little regarded as hitherto.

Halley even described non-astronomical phenomena that are so familiar to eclipse observers: "I forbear to mention the Chill and Damp which attended the Darkness of this Eclipse, of which most Spectators were sensible, and equally Judges. Nor shall I trouble you with the Concern that appear'd in all Sorts of Animals, Birds, Beasts, and Fishes upon the Extinction of the Sun, since our selves could not behold it without some sense of Horror."

A second, shorter eclipse article in *Philosophical Transactions* (Halley, 1715b) provides further information: "Since the Publication of the large Account we gave in Phil. Trans. No. 343 of what was observed in England, and particularly at London, of this Eclipse, we have received from foreign Parts the following Observations; which seem not unworthy the Acceptance of the Curious." Observations follow from at sea near Teneriffe, Nuremburg, Hamburg, Kiel, Berlin, Frankfort, and the Hague. Observations were limited to timing, with no description of the appearance of the sun. Only the conclusion is non-mathematical: "As to the Darkness, it was such that they could scarce distinguish one another: and besides Jupiter, Mercury and Venus; of the Fixt Stars Cassiopea, Capella, Oculus Tauri and Orion (Sirius not being yet risen) were visible."

4 THE ACTUAL ECLIPSE PATH OF 1715

After the eclipse, Halley plotted the actual path on a new engraving (Figure 3). [Williams (1996) draws this actual path as a dotted line on the original map.] Halley discussed his own observations and those of others in the *Philosophical Transactions of the Royal Society* (1715a). He modified the broadside to read, "A Description of the Passage of the Shadow of the Moon over England as it was Observed in the late Total Eclipse of the Sun April 22d: 1715 Manè."

Gingerich (1992) discusses the difference in the actual path from the predictions of Halley and of Whiston. Dunham *et al.* (1980) reported a possible change in the size of the sun based on changes in the widths of eclipse paths between the observations collected by Halley in 1715 and those collected by their group from grazing eclipse paths viewed from the edges of totality and Ribes *et al.* (1987) reported a change based on old observations made at the Paris Observatory. Pasachoff and Nelson (1987), though, found from my timing of the duration of totality at the 1984 eclipse in Hula, Papua New Guinea, that the predictions and timing of the beads are too uncertain to allow the method to be reliably used. Morrison, Stephenson, and Parkinson (1988) used their own observations and also did not confirm that the sun's diameter had changed measurably since 1715.

Notable on the post-eclipse 1715 map is the addition of the predicted path for the forthcoming 1724 eclipse. The new text says,

Since the Publication of our Predictions of this Eclipse has had the desired effect, and many curious Persons have been excited thereby to communicate their Observations from most parts of the Kingdom; we thought it might not be unacceptable to represent after the same manner the passage of the Shade, as it really happened; whereby it will appear that tho' our Numbers pretend not to be altogether perfect, yet the correction they need is very small.

At *London* the Eclipse was carefully Observed to begin at $8^h.6'$ manè, and to become Total at $9^h.9'$. It continued Total 3'.23", and ended at $10^h.20'$. And by the Accounts we have received from Abroad, the Center of the Shade past nearly over *Plymouth, Exeter, Buckingham* and *Huntingdon,* leaving *Bath* and *Lynn* a little on the left, and *Oxford* and *Ely* on the right. The Southern limit past over *Cranbook* in *Kent*, leaving *Newhaven* and *Canterbury* a very little without: And the Northern limit entered on the Coast of *Wales* in *S^t.Bride's-bay*, & left *England* near *Flamborough-head,* all which the Map more particularly describes. The greater diameter of y^e Shade having been 170 Geog:Miles or Minutes, and ye lesser 110.

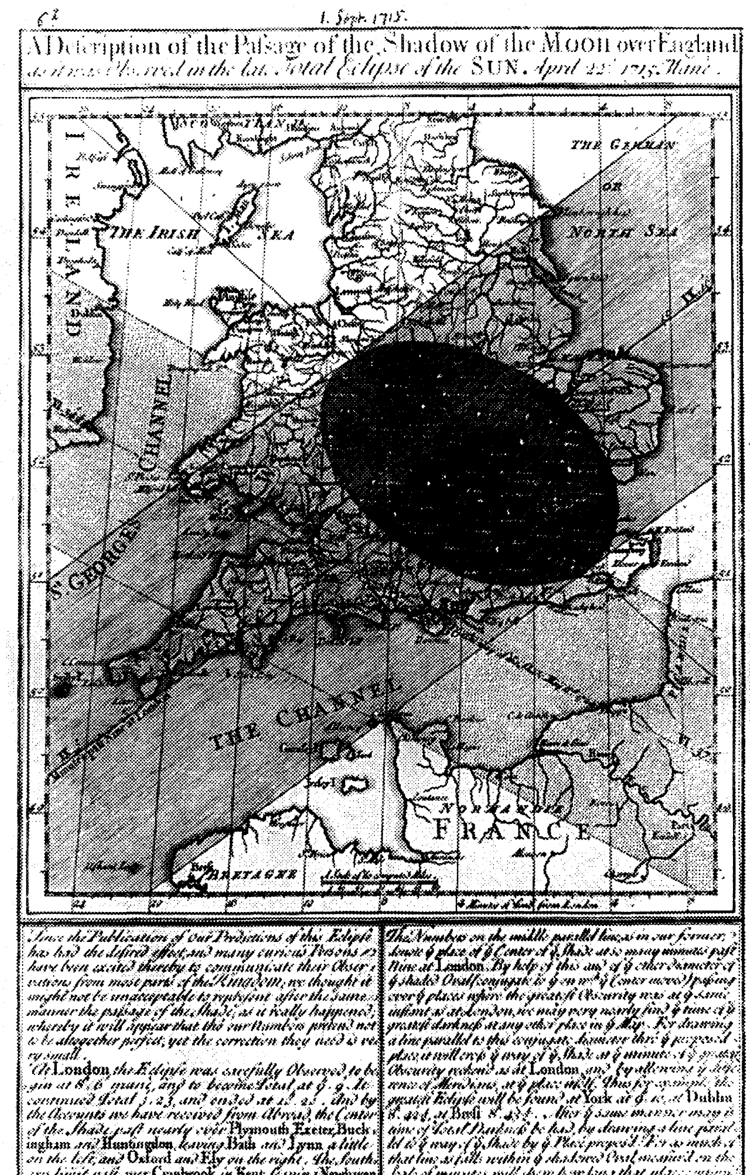

Figure 3. Drawn soon after the 22 April 1715 total solar eclipse, Halley's map shows the eclipse's actual path. The predicted path of the 1724 eclipse has been added. (With the permission of the Houghton Library, Harvard University. EB7 H1552 715d2)

The Numbers on the middle parallel line, as in our former, denote y^{e} place of y^{e} Center of y^{e} Shade at so many minutes past Nine at *London.* By help of this and of y^{e} other diameter of y^{e} shaded Ovall (conjugate to y^{e} on[e] wth y^{e} Center moved) passing over y^{e} places where the greatest Obscurity was at y^{e} same instant as at London, we may very nearly find y^{e} time of y^{e} greatest darkness at any other place on y^{e} Map. For drawing a line parallel to this conjugate diameter thrô y^{e} proposed place, it will cross y^{e} way of y^{e} Shade at y^{e} minute of y^{e} greatest Obscurity reckon'd as at *London*, and by allowing y^{e} difference of Meridians, at y^{e} place itself. Thus for example, the greatest Eclipse will be found at *York* at 9^{h}.10', at *Dublin* 8^{h}.42' ½, at *Brest* 8^{h}.43' ½. After y^{e} same manner may y^{e} time of Total Darkness be had, by drawing a line parallel to y^{e} way of y^{e} Shade by y^{e} Place propos'd: For as much of that line as falls within y^{e} shadowed Oval, measur'd on the Scale of minutes, will shew how long that place continu'd within the true Shade quam proxima.

We give you likewise y^{e} Transit of y^{e} Shade, as it will pass over y^{e} West of *England* in y^{e} Eclipse y^{t} will be Anno 1724 May 11.P.M. in w^{ch} ye Northern limit passes very near *Dublin & Oxford.* But it will scarce reach *London* where it begins at 5^{h}.39', is greatest at 6^{h}.35' ½, and ends at 7^{h}.27' ½ in the Evening.

The credit reads, "Engrav'd and Sold by John Senex at the Globe in Salisbury Court near Fleetstreet."

5 PREPARING FOR THE 1724 ECLIPSE

In 1722, Halley (1722) reported, in Latin, timing of a partial eclipse he observed. Observations by others, described in English, followed.

Prior to the 1724 total eclipse, he released another copy of his earlier map (Figure 4). The heading was the only item changed, being transformed to read: " A Description of the Passage of the Shadow of the Moon over England In the Total Eclipse of the Sun on the 11th day of May 1724 in the Evening. Togather with the Passage of the Shadow as it was Observ'd in the last Total Eclipse of 1715. By D^{r}.E. Halley, R.S.S. Astro^{r}:Roy^{l}." Halley was Royal Society Secretary (R.S.S.) as well as Astronomer Royal. The credit caption is also slightly different, representing only a change in location of the same publisher: "Engrav'd and Sold by John Senex at the Globe ag^{t}. S^{t}. Dunstans Church Fleetstreet." The Houghton copy of this map dated, in the same hand as before, "Novemb. 1723." It sold for only fivepence (5^{d}).

6 PATH OF THE 1724 ECLIPSE

Halley completely redrew his map prior to the 1724 eclipse (Figure 5). London was just north of the path of totality. The new map shows the Continent as far as Venice, which was on the centre line of totality. The ellipse of totality is no longer shown. Gingerich (1992) describes how William Whiston, who had succeeded Isaac Newton in his professorial chair at Cambridge, had made predictions showing the path about 40 km farther north, but how the actual path had gone approximately midway between Halley's and Whiston's predictions.

The text below the map is much shorter, referring to an eclipse that had been visible over the Continent but not the British Isles. (The previous total eclipses visible from parts of England were, barely, in 1652 and, also in the west only, in 1598.) The text stated:

Figure 4. Reprinted shortly before the 1724 eclipse, Halley's map is changed only in the accompanying written text since its 1715 publication. (With the permission of the Houghton Library, Harvard University. EB7 H1552 715d2b)

"This Eclipse being the Return of that wherin the Shadow past over Europe on the first of May 1706, and which was curiously Observed in several Places; we presume the Description we give of it may be very near the Truth, as far at least as the Geographical Mapp may be depended upon. Where it shall be Observed with proper Instruments and due care, we may be assured of the Longitude of those Places; And in order further to perfect our Science, 'tis hoped the Curious that may happen to be near the Limits of the total Shade, where the Sun will be missing but a few Seconds, will be so kind as to transmit their Observations of y^e^ continuance of Totality; there being nothing requisite thereto, but to count y^e^ Vibrations of y^e^ Pendulum Clock, whilst y^e^ Sun is absent. The Mapp shows where we expect it, y^e^ Northern edg of y^{e} Shade leaving Dublin Oxford & London very little wthout it, & y^{e} Souther^{n} limit including Cork & Kinsale in Ireland, & in England Plymouth & Dartmouth. At London we compute y^{e} Beginning at 5^{h}.40'.P.M. y^{e} Middle when it will be nearly Total at 6^{h}.37'. & y^{e} End 7^{h}.29'. We wish our Astronomical Friends a Clear Sky.

The same publisher did this map from the same address: "Engrav'd and Sold by John Senex at the Globe against S^{t}. Dunstans Church in Fleetstreet. Price 1^{s}." The Houghton copy is dated in hand about two weeks before the eclipse, and priced at tenpence (10^{d}) Since one shilling was 12 pence, perhaps our purchaser of the time was given a slight discount from the list price. One of the pre-eclipse 1715 maps sold at the auction of the Haskell F. Norman Library of Science and Medicine: Part 2, The Age of Reason, at Christie's (1998) in New York on June 15-16, 1998, for a total price of over $15,000 (Lot 493, 455x285 mm, $13,800 plus buyer's premium), far exceeding the pre-auction estimate of $1,500-2,000.

William Whiston's map of the 1724 eclipse (Figure 6) is dated, in the engraving, April 27, 1724. It is labelled "The Transit of the Total Shadow of the Moon over Europe in the Eclipse of the Sun May 11th. 1724. in the Evening, described by Will. Whiston M.A." Times of the eclipse for various locations are printed at the bottom of the map, with times of the partial eclipse visible at London printed on the left side.

Figure 5. Since the path of totality crossed more of Europe in 1724 than it had in 1715, Halley's map of the predicted path, published closer to the date of the eclipse, showed more of the European Continent. (With the permission of the Houghton Library, Harvard University. EB7 H1552 724d)

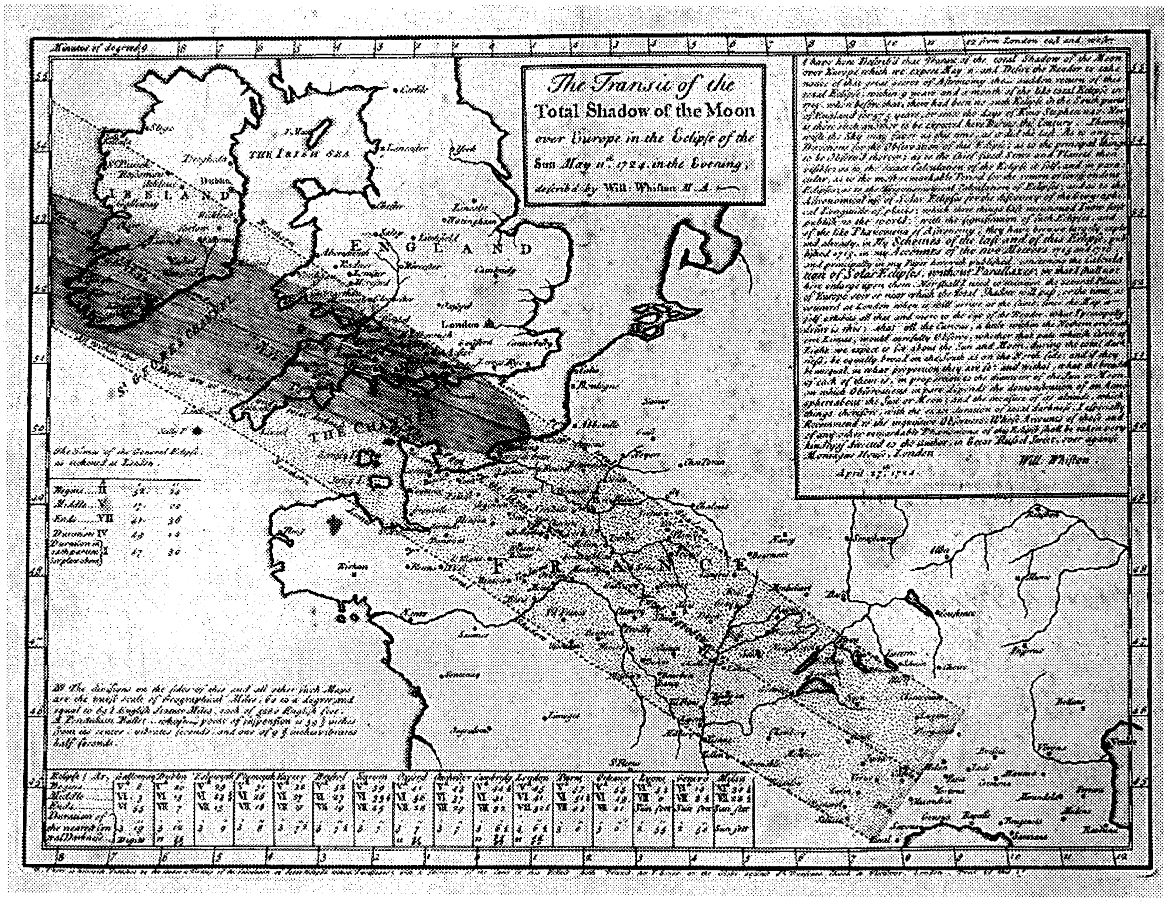

Figure 6. William Whiston's map of the path of the 1724 eclipse. (With the permission of the Royal Astronomical Society)

Armitage (1997) calls it "an obvious and rather crude attempt to copy Halley's successful formula." For the 1724 maps, Halley omitted the shape of the totality oval while Whiston included it, a very extended oval since the end of totality occurred in France and the projection was thus extreme. Armitage (1997 and Gingerich (1992) each report that the actual path was halfway between Halley's and Whiston's predictions, which differed by 25 miles.

7 THE PATH OF THE 1999 ECLIPSE

A modern map of the European section of the 1999 total eclipse appears in Espenak and Anderson (1997) (Figure 7). It shows how closely the path of this eclipse corresponds to that shown in Halley's map of 1724. That it resembles Halley's maps so closely is coincidental, as can be seen by the different appearance of the maps we drew of the same eclipse (Pasachoff and Covington, 1993).

Observers were largely successful in viewing the 1715 eclipse but largely foiled by clouds in 1724. One can do no better for the 1999 and future eclipses than to quote Halley's wish from the 1724 map: "We wish our Astronomical Friends a Clear Sky."

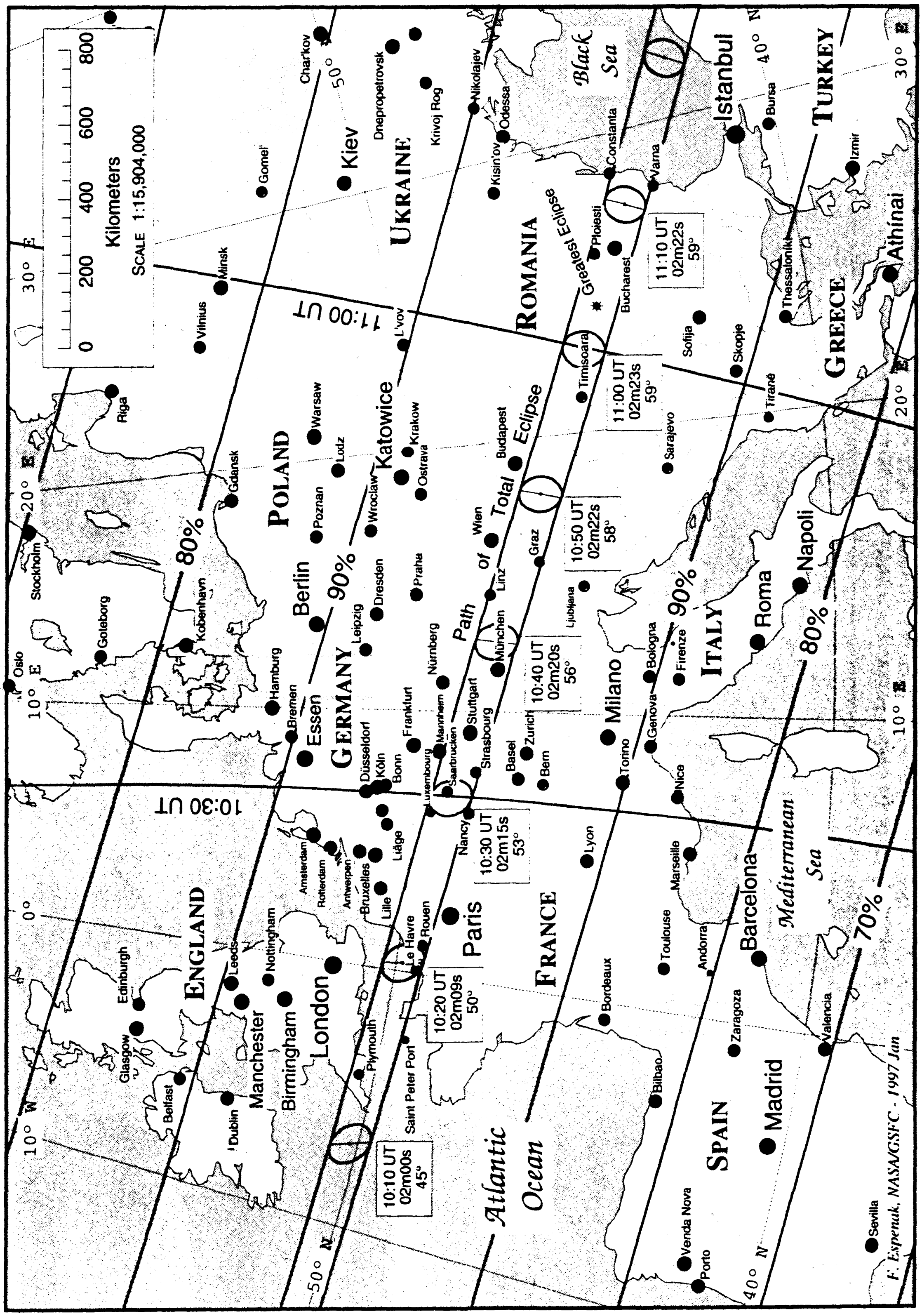

Figure 7. A current map of the predicted path of the 1999 August 11 total solar eclipse, as it appeared in the NASA Reference Publication without knowledge of Halley's older map. (Courtesy of Fred Espenak, NASA Goddard Space Flight Center.)

8 ACKNOWLEDGMENTS

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9 REFERENCES

Armitage, Geoff, 1997. *The shadow of the moon: British solar eclipse mapping in the eighteenth century.* Tring, Herts: Map Collector Publications Ltd.

Christie's, 1998. Haskell F. Norman Library of Science and Medicine: Part 2, The Age of Reason, lot 493, pp. 190-191.

Cook, Alan, 1998. *Edmond Halley: Charting the Heavens and the Seas*, Clarendon Press, Oxford University Press.

Espenak, Fred and Anderson, Jay, 1997. *Total Solar Eclipse of 1999 August 11.* NASA Goddard Space Flight Center, Greenbelt, Maryland, (NASA Reference Publication 1398).

Dunham, David W., Sofia, Sebastiano, Fiala, Alan D., Herald, David and Muller, P. M., 1980. *Science* **210:**1243-1245.

Gingerich, Owen, 1992. Eighteenth-Century Eclipse Paths. In O. Gingerich, *The Great Copernicus Chase and Other Adventures in Astronomical History.* Cambridge University Press, Cambridge, pp. 152-159 [an article reprinted from *Sky & Telescope*, **62**:324-327, 1981].

Golub, L. and Pasachoff, J.M., 1997. *The Solar Corona.* Cambridge University Press, Cambridge.

Halley, Edmond, 1715a. Observations of the late Total Eclipse of the Sun on the 22d of April last ... *Philosophical Transactions of the Royal Society* **29:**245-262.

Halley, Edmond, 1715b. Some Accounts of the late great Solar Eclipse on April 22, 1715, mane. *Philosophical Transactions of the Royal Society* **29:**314-316.

Jones, B.Z. and Boyd, L.G., 1971. *The Harvard College Observatory.* Harvard University Press, Cambridge, Mass.

Meadows, A.J., 1970. *Early Solar Physics.* Pergamon Press, Oxford

Morris, Bob, 1999. Total Eclipse of Titanic. In *Ottawa Citizen*, *The Citizen's Weekly*, Sunday, March 21, 1999, pp. D12-D13.

Morrison, L.V., Stephenson, F.R. and Parkinson, J., 1998. *Nature* **331:**421-423.

New York Times, The, 1925. for 25 January 1925. page 1.

Olson, R.J.M. and Pasachoff, J.M., 1989. Historical Comets over Bavaria: *The Nuremberg Chronicle* and Broadsides. In *Comets in the Post-Halley Era,* Proceedings of International Astronomical Union Symposium #116. Kluwer, Dordrecht, Holland/Boston/London, pp. 1309-1341.

Olson, R.J.M. and Pasachoff, J.M., 1998. *Fire in the Sky: Comets and Meteors, the Decisive Centuries, in British Art and Science.* Cambridge University Press, Cambridge, with the support of Gresham College, London.

Pasachoff, J.M., 1999. Halley and his maps of the total eclipses of 1715 and 1724. *Astronomy & Geophysics*, **40**(2):2.18-2.21.

Pasachoff, J.M. and Covington, M.A., 1993. *The Cambridge Eclipse Photography Guide.* Cambridge University Press, Cambridge.

Pasachoff, J.M. and Nelson, B.O., 1987. Timing of the 1984 Total Solar Eclipse and the Size of the Sun, *Solar Physics,* **108**:191-194.

Ribes, E., Ribes, J.C. and Barthalot, R., 1987. *Nature* **326:**52-55.

The Globe (Toronto), 1925. for 26 January 1925, page 1.

Williams, S, 1996. *UK Solar Eclipses from Year 1.* Clock Tower Press, Leighton Buzzard, UK.

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Note added in proof:
Alice N. Walters, in "Ephemeral Events: English Broadsides of Early Eighteenth-Century Solar Eclipses," *History of Science*, **37**:1-43, March 1999, discusses the eclipse maps of Halley and of Whiston, as well as the work of the bookseller and cartographer Senex and the the broadsides of Benjamin Martin.

Recent publications relating to the history of astronomy

Books and Pamphlets

Après Galilée. Science et foi: nouveau dialogue. Sous la direction du cardinal Paul Poupard. 1. Une déjà longue histoire. Paris, Descles de Brouwer, 1994. p. 17–107.

Contents: 1. Mayaud, P. N. Deux textes au cœur du conflit: entre l'Astronomie Nouvelle et l'Écriture Sainte: la lettre de Bellarmin à Foscarini et la lettre de Galilée à Christine de Lorraine.—2. Poupard, P. Compte rendu des travaux de la commission pontificale d'études de la controverse ptoléméo-copernicienne aux XVI^{e}-XVII^{e} siècles.—John Paul II, Pope. Discours à l'Académie pontificale des sciences.

Arkheoastronomiiâ—problemy stanovleniiâ. Tezisy dokladov mezhdunarodnoĭ konferentŝii (15–18 oktiâbriâ 1996 g.). Moskva, Rossiĭskaiâ akademiiâ nauk, Institut arkheologii, 1996. 159 p. illus.

Contents: Predislovie.—Antonova, E. V. Spetŝifika uslovnykh izobrazheniĭ dopis'mennykh kul'tur i problema ikh interpretatŝii kak znakov svetil.—Ashikhmina, L. I. Sviâtilishche—observatoriiâ (?) Vomyn"iag na Verkhneĭ Vychegde.—Bannikov, K. L. Baal-baly v pazyrykskoĭ kosmologii. (Po materialam polevykh issledovaniĭ na plato Ukok.)—Bekbasarov, N. M. Astronomicheskie aspekty kurganov s "usami."—Belokon', A. T. Figury pustyni Naska kak vozmozhnyĭ arkheoastronomicheskiĭ ob'ekt.—Berezkin, IÛ. E. Areal'nye zakonomernosti v soliârno-lunarnoĭ mifologii indeĭtŝev Latinskoĭ Ameriki i zaselenie Novogo Sveta.—Varenov, A. V. Otrazhenie kalendarno-astronomicheskikh sootnosheniĭ v chislennom sostave i strukture in'skikh voinskikh podrazdeleniĭ.—Viktorova, V. D. Mifologicheskaiâ kartina mira ėneoliticheskogo naseleniiâ gornolesnogo Zaural'iâ.—Vlasov, V. G. Agrarnyĭ kalendar' i narodnaiâ astronomiiâ v drevneĭ Rusi. Podkhody k interpretatŝii krugovogo ornamenta.—Vokhmentŝev, M. P. Zaural'skie pamiâtniki s krugovoĭ planirovkoĭ.—Galkin, L. L. Dvenadtŝatiletniĭ zhivotnyĭ tsikl na monetakh zolotoĭ ordy.—Gogin, N. D., and N. O. Kirsanov. Ob odnoĭ modeli Mira u pribaltiĭskikh finnov.—Gusakov, M. G. Dneprovskie gorodishcha-sviâtilishcha lesnoĭ polosy. (Problemy arkheoastronomii.)—Dement'ev, M. S. Sravnenie (drevnimi astronomami) zvezdnoĭ karty neba a geograficheskoĭ kartĭo zemli.—Demeshchenko, S. A. Diskovidnye podelki v kul'ture paleoliticheskogo cheloveka.—Dmitrieva, I. V., E. P. Zaborova, and V. N. Obridko. Stikhiĭnye bedstviiâ i solnechnaiâ aktivnost' (po dannym letopiseĭ).—Devlet, E. G. Astronomicheskie ob'ekty v naskal'nom iskusstve.—Ershova, G. G. Astronomicheskie teksty na arkheologicheskikh pamiâtnikakh maĭiâ.—Zhitomirskiĭ, S. V. "IÂvleniiâ" Arata—unikal'nyĭ pamiâtnik istorii astronomii.—Zhuravlev, A. P. Kul'tovyĭ kompleks Pegrema-40.—Karapet'iântŝ, A. M. Problema proiskhozhdeniiâ drevnekitaĭskogo Zodiaka.—Kaurov, Ė. N. Istoki i ėvoliûtŝiiâ drevnekitaĭskikh astronomicheskikh nabliûdeniĭ.—Kirillov, A. K., and G. B. Zdanovich. Arkheoastronomicheskie issledovaniiâ na gorodishche Arkaim (epokha bronzy).—Kifishin, A. G. "Otkrytoe" i "zakrytoe" nebo po dannym protoshumerskogo arkhiva Kamennoĭ Mogily i shumero-vavilonskim traktatam.—Klimka, L. A. Ėtnokosmologiiâ i arkheoastronomiiâ v Baltiĭskikh stranakh.—Kovaleva, V. T. Kosmogonicheskie predstavleniiâ naseleniiâ tashkovskoĭ kul'tury.—Kosarev, M. F. Nekotorye aspekty iâzycheskogo kosmologicheskogo znaniiâ (po uralo-zapadnosibirskim arkheologo-ėtnograficheskim materialam).—Kochmar, N. N., A. V. Pen'kov, and P. S. Knurenko. Pervye opyty arkheoastronomicheskogo issledovaniiâ pisanitŝ IÂkutii.—Larichev, V. E. Skul'pturnoe izobrazhenie surka iz mal'ty (rasshifrovka znakovoĭ zapisi i semantika obraza).—Marsadolov, L. S. Drevnee sviâtilishche na gore Ocharovatel'noĭ v Zapadnom Altae.—Marsadolov, L. S., and V. L. Gorshkov. Astronomicheskie raschety dliâ sviâtilishcha na gore Ocharovatel'noĭ.—Nagovitŝyn, IÛ. A. Podkhod mnogomernoĭ statistiki k issledovaniiû temperaturnykh anomaliĭ pogody po materialam russkikh 1000-

letnikh khronik.—Nagovitŝyn, IÛ. A. Rekonstruktŝiiâ solnechnoĭ tŝiklichnosti v XII-XVII vekakh na osnove nelineĭnoĭ matematicheskoĭ modeli.—Nikitin, V. V. Kalendar′ v ornamente posudy i ukrasheniiâkh finno-ugrov Povolzh′iâ i Urala.—Otroshchenko, V. V. K voprosu o modeli mira u naseleniiâ srubnoĭ obshchnosti.—Povileĭko, R. P., and T. D. Petrovskaiâ. Zakon "Velikolepnoĭ semerki" 7+2. (Ob″em vospriiâtiiâ informatŝii chelovekom segodniâ i v proshlom. K postanovke problemy.)—Potemkina, T. M., and V. A. IÛrevich. Drevneĭshaiâ "astronomicheskaiâ observatoriiâ" na territorii Rossii.—Potemkina, T. M. Kalendarno-obriâdovaiâ praktika naseleniia Zaural′iâ v III tys. do n.ė.—Raevskiĭ, D. S. Zodiakal′naiâ simbolika na predmetakh kelermesskogo kurgana.—Salles, R., and D. D. Polozhentŝev. Astronomicheskiĭ aspekt drevnego arkheologicheskogo pamiâtnika Bolivii "Tiauanako."—Sviâtopolk-Chetvertynskiĭ, I. A. Vliiânie faz Luny na bozhestvennuiû i chelovecheskuiû sfery soglasno shumero-vavilonskoĭ traditŝii. (Neskol′ko slov o prodvizhenii deshifrovki shumero-vavilonskoĭ formul′noĭ sistemy.)—Fedorova, I. K., and O. M. Fedorova. Zodiak i Mlechnyĭ Put′ v predstavleniiâkh drevnikh polineziĭtŝev.—Khudiâkov, IÛ. S. Istoriko-arkheologicheskie aspekty izucheniiâ svidetel′stv stolknoveniiâ zemli s opasnymi kosmicheskimi ob′ektami.—Chudinov, V. A. Nekotorye astronomicheskie terminy russkogo korneslova kak vyrazhenie drevneĭshego vzgliâda na mir.—Chudinov, V. A. Astronomicheski-ritual′naiâ interpretatŝiiâ risunka-nadpisi iz Kammenoĭ Mogily.—Shilov, IÛ. A. Stanovlenie arkheoastronomii na Ukraine (istoriograficheskiĭ ocherk).—IÛrevich, V. A. Astronomicheskai, orientatÀii, amerikanskikh arkheologicheskikh pamiât-nikov.—IÛrevich, V. A. Astronomicheskie napravleniiâ arkheoastronomii.—Spisok uchastnikov mezhdunarodnoĭ konferentŝii "Arkheoastronomiiâ: problemy stanovleniiâ."

Astronomiiâ na krutykh povorotakh XX veka. Redaktor-sostavitel′: Eremeeva A. I. Dubna, Feniks, 1997. 473 p. illus., map, ports.

Errata sheet laid in.

Eighty-one papers presented at a conference held at Pulkovo in April 1995 to mark the 50th anniversary of the victory over Nazi Germany.

Includes an English translation by I. B. Pustyl′nik of Eremeeva's introductory essay, "Astronomy at the Sharp Turns of the XXth Century History" (p. 12–18).

The papers are organized into seven sections, the titles of which are given below.

Contents: Glava I. Kontrasty razvitiiâ sovetskoĭ astronomii v predvoennoe desiâtiletie.—Glava II. Astronomy na fronte. ch. 1. Geroi ne umiraiût v nashe pamiâti. ch. 2. Velikaiâ otechestvennaiâ voĭna v vospominaniiâkh astronomov-frontovikov.—Glava III. Astronomiiâ dliâ fronta.—Glava IV. Sud′by astronomicheskikh tŝentrov v raĭonakh boevykh destviĭ, v blokade i okkupatŝii.—Glava V. Sozdanie novykh i deiâtel′nost′ starykh astronomicheskikh tŝentrov v tylu.—Glava VI. Voennaiâ tekhnika i noveĭshaiâ tekhnologiiâ na sluzhbe astronomii.—Glava VII. Uspekhi astronomii v gody voĭny i v pervoe poslevoennoe desiâtiletie.

La Bellezza dell'universo. A cura di Francesco Bertola, Massimo Calvani, Umberto Curi, Massimo Donà. Padova, Il Poligrafo, 1996. 126 p. illus. (Percorsi della scienza; storia, testi, problemi, 6)

Papers presented at a conference held in Venice, December 1993.

Contents: Sini, C. Il cosmo e il caos.—Dallaporta, N. Bellezza ed arte nell'ambito dei mondi tradizionali.—Pasqualotto, G. Forme orientali di universo.—Pomodoro, G. La bellezza dell'universo nella distanza attuale fra arte e scienza.—Kafka, F. Che cos'è la bellezza? Sulla teoria sistematica della creazione.—Boniolo, G. Vedo le stelle in cielo ... —Bertotti, B. Criteri estetici in fisica teorica.—Sciama, D. W. Contributo alla discussione.

Blaauw, Adriaan. ESO historical archives (EHA). Inventory per December 1992. Garching, European Southern Observatory [1992?] 40 leaves. facsims.

Bradshaw, Joseph. The night sky in Egyptian mythology. London, H. Bradshaw, 1997. 1–178, [62], 179–182 p. illus.

Obtainable from H. Bradshaw, 85 Balfour Road, London N5 2HE.

Doscientos aniversario del Almanaque Náutico y Efemérides Astronómicas, 1792–1992. Volumen conmemorativo. San Fernando, Real Instituto y Observatorio de la Armada, 1992. 80 p. illus., facsims., ports. (Boletín ROA, no. 1/92)

3 × [Dreimal] Foerster. Beiträge zu Leben und Werk von Wilhelm Foerster, Friedrich Wilhelm Foerster und Karl Foerster. Hrsg. im Auftrag des URANIA-Vereins "Wilhelm Foerster" Potsdam e.V. von Mathias Iven. Milow, Schibri-Verlag, 1995. 267 p. illus., facsims., ports.

Partial contents: Iven, M. "3 × Foerster" und die Potsdamer URANIA.—Zu Leben und Werk von Wilhelm Foerster.—Ausgewählte Veröffentlichungen.—Foerster, K. Der Mann, der neun Jahrzehnte erfüllte. Zum 100. Geburtstag des Astronomen Wilhelm Foerster.—Feyl, R. Wilhelm Foerster.—Lührs, O. Wilhelm Foerster und die Gründung der Urania.—Tiemann, K. H. Wilhelm Julius Foerster und die "Vereinigung von Freunden der Astronomie und kosmischen Physik" (1891 bis 1914).—Zenkert, A. Der Einfluss Wilhelm Foersters auf Bruno H. Bürgel.—Buschmann, E. Wilhelm Foersters Einfluss auf die Entwicklung der Höheren Geodäsie.—Kummer, H. J. Wilhelm Foerster und Ludwig Strasser—ein Freundschaft im Dienste der Deutschen Chronometrie.—Dick, W. R. Über das Schicksal des Nachlasses von Wilhelm Foerster.—Wilhelm Foesters Briefe an Eduard Schönfeld.

Edson, Evelyn. Mapping time and space: how medieval mapmakers viewed their world. London, British Library, 1997. 210 p. facsims. (part col.) (The British Library studies in map history, v. 1)

See particularly chapter 4, "Space and Time in the Computus Manuscript" (p. 52–71), and chapter 5, "Three Maps in Computus Manuscripts" (p. 72–96).

Foderà Serio, Giorgia, *and* Donatella Randazzo. Astronomi italiani dall'unità d'Italia ai nostri giorni: un primo elenco. Firenze, Società astronomica italiana editore, 1997. 116 p.

Small portraits of 36 of the astronomers are reproduced on the outside front cover of the volume.

Gandt, François de. Force and geometry in Newton's *Principia.* Translated by Curtis Wilson. Princeton, N.J., Princeton University Press, 1995. xiv, 296 p. illus.

Translation of *Force et géométrie: les "Principia" de Newton dans le XVIIème siècle.*

George Gamow Symposium, *George Washington University, 1996.* The George Gamow Symposium. Sponsored by the George Washington University and the Carnegie Institution of Washington, 12 April 1997 [i.e. 1996] Edited by E. Harper, W. C. Parke, and G. D. Anderson. San Francisco, Astronomical Society of the Pacific, 1997. 157 p. illus., facsims., ports. (Astronomical Society of the Pacific conference series, v. 129)

"Appendix: The Publications of George Gamow": p. 141–151.

Partial contents: Stuewer, R. H. Gamow, alpha decay, and the liquid-drop model of the nucleus.—Bethe, H. Influence of Gamow on early astrophysics and on early accelerators in nuclear physics.—Alpher, R. A. Cosmochemistry and the early universe.—Herman, R. The prediction of the cosmic microwave background radiation.—Rubin, V. C. What George Gamow did not know about the universe.—Rich, A. Gamow and the genetic code.—Teller, E. Some personal memories about George Gamow.—Reminiscences of George Gamow [presented by Igor Gamow, Marshall Nirenberg, James Follin, Vera Rubin, Alexander Rich, Ralph Alpher, Robert Herman, and Philip Abelson]

Gillispie, Charles C. Pierre-Simon Laplace, 1749–1827; a life in exact science. With the collaboration of Robert Fox and Ivor Grattan-Guinness. Princeton, N.J., Princeton University Press, 1997. 322 p. illus., port.

Graf-Stuhlhofer, Franz. Humanismus zwischen Hof und Universität. Georg Tannstetter (Collimitius) und seine wissenschaftliches Umfeld im Wien des frühen 16. Jahrhunderts. Wien, WUV-Universitätsverlag, 1996. 192, [20] p. illus., facsims., maps, ports. (Schriftenreihe des Universitätsarchivs Universität Wien, 8. Bd.)

"Georg Tannstetter, genannt Collimitius (1482–1535), und sein Schaffen als Mathematiker und Astronom, wird in diesem Band ausführlich dokumentiert."

International Astronomical Union. Symposium, *172d, Paris, 1995.* Dynamics, ephemerides and astrometry of the solar system. Proceedings of the 172nd Symposium of the International Astronomical Union, held in Paris, France, 3–8 July 1995. Edited by S. Feraz-Mello, B. Morando and J. E. Arlot. Dordrecht, Boston, Kluwer Academic Publishers, 1996. xviii, 508 p. illus., facsims., port.

Partial contents: Arlot, J. E., and S. Ferraz-Mello. Bruno Morando (1931–1995). —Morando, B. Deux cents ans de mécanique céleste sous les auspices du Bureau des longitudes.—Pang, K. D., and K. K. C. Yau. The need for more accurate 4000-year ephemerides, based on lunar and spacecraft ranging, ancient eclipse and planetary data.—Seidelmann, P. K. Evolution of ephemerides representation and diffusion.—Débarbat, S. V. Des éphémérides astronomiques annuelles en préliminaire à l'Annuaire du Bureau des longitudes.—Toulmonde, M. Les diamètres du Soleil dans la *Connaissance des temps* depuis 1795.

Morando's paper is preceded by a lengthy abstract in English.

Krauss, Rolf. Astronomische Konzepte und Jenseitsvorstellungen in den Pyramidentexten. Wiesbaden, Harrassowitz, 1997. 297 p. illus. (Ägyptologische Abhandlungen, Bd. 59)

Leopardi, Giacomo. Storia della astronomia dalla sua origine fino all'anno MDCCCXIII. Con uno scritto di Armando Massarenti e un'appendice di Laura Zampieri. Milano, La Vita felice, 1997. 459 p. (Philobiblon, 2)

Contents: Massarenti, A. Leopardi e la leggerezza delle scienze.—Introduzione.—1. Storia della astronomia dalla sua origine sino alla nascita di Talete.—2. Storia dell'astronomia dalla nascita di Talete sino a quella di Ptolomeo.—3. Storia dell'astronomia dalla nascita di Ptolomeo sino a qualla di Copernico.—4. Storia dell'astronomia dalla nascita di Copernico sino alla cometa dell'anno 1811.—5. Progressi fatti dalla astronomia.—Giunte alla storia dell'astronomia.—Opere delle quali si è fatto uso nello scrivere la storia della astronomia.—Dissertazione sopra l'origine, e i primi progressi dell'astronomia. 1814.—Zampieri, L. Appendice: Annotazioni leopardiane inedite relative alla *Storia dell'astronomia*.

Lindgren, Uta. Die Artes liberales in Antike und Mittelalter. Bildungs- und Wissenschaftsgeschichtliche Entwicklungslinien. München, Institut für Geschichte der Naturwissenschaften, 1992. 161 p. illus., facsims., port. (Algorismus, Heft 8)

Littmann, Mark. The heavens on fire: the great Leonid meteor storms. Cambridge, New York, Cambridge University Press, 1998. 349 p. illus., facsims., ports.

Methuen, Charlotte. Kepler's Tübingen: stimulus to a theological mathematics. Aldershot, Hants, Brookfield, Vt., Ashgate, 1998. 280 p. maps. (St Andrews studies in Reformation history)

Miller, Dorcas S. Stars of the first people: native American star myths and constellations. Boulder, Colo., Pruett Pub. Co., 1997. xv, 346 p. illus., maps.

Oestmann, Günther. Schicksaldeutung und Astronomie: der Himmelsglobus des Johannes Stoeffler von 1493. Mit Beiträgen von Elly Dekker und Peter Schiller. Ausstellungskatalog. Stuttgart, Württembergisches Landesmuseum Stuttgart, 1993. 71 p. illus. (part col.), facsims., ports.

The exhibit was held Dec. 2, 1993–Mar. 6, 1994.

Ondřejovská hvězdárna, 1898–1998. Sborník o české a moravské astronomii uspořádaný ke 100. výročí Ondřejovské hvězdárny a 650. výročí University Karlovy. Uspořádali Petr Hadrava, Marian Karlický, Jan Palouš, Martin Šolc. Praha, Astronomický ústav AV ČR v nakl. Vesmír, 1998. 373 p. illus. (part col.), facsims. (part col.), maps (part col.), ports.

Contents: Hadrava, P., M. Karlický, J. Palouš, and M. Šolc. Předmluva.—Historické kořeny astronomie v Čechách a na Moravě. Pleslová-Štiková, E. Zdeněk Horský: protagonista středoevropské archeoastronomie (in memoriam). Hadravová, A., and P. Hadrava. Středověká astronomie v Čechách. Hadravová, A., and P. Hadrava. Astronomie v rudolfínské Praze. Šolcová, A. Matematika a astronomie v době pobělohorské. Šíma, Z. Klementinská hvězdárna. Vetešník, M. Astronomie v Brně včera, dnes a zítra.—Zakládání hvězdárny. Šíma, Z. Jan Neruda a rozvoj české astronomie. Fričová-Brázdilová, A., and J. Brázdil. Historie založení hvězdárny v Ondřejově. Kopecký, M. Historický archiv astronomické observatoře v Ondřejově. Vondrák, J. Historie cirkumzenitálu. Krejčí, G. Knihovna bratří Fričů. Jarolím, M. Knihovna Astronomického ústavu AV ČR v minulosti a současnosti. Polášková, Š. Historie parku ondřejovské observatoře.—Historie hvězdárny a Astronomického ústavu Akademie věd ČR. Šolc, M. František Nušl, ČAS a Ondřejov. Plavec, M. Ondřejovská hvězdárna za druhé světové války. Šolc, M. František Link. Hadrava, P. Historie gravitačních čoček. Šíma, Z. Dr. Bohumil Šternberk. Ptáček, V., L. Webrová, and R. Weber. Časová služba. Zacharov, I., and L. Neužil. Vysoká atmosféra. Ceplecha, Z. Výzkum meteorů. Šimek, M. Meteorická radioastronomie. Ambrož, P., V. Bumba, and Z. Švestka. Sluneční astronomie. Plavec, M. Přes překážky ke hvězdám. Perek, L., J. Zicha, and P. Koubský. Dvoumetrový dalekohled. Perek, L., and L. Kohoutek. Hvězdná dynamika a planetární mlhoviny. Ruprecht, J. Otevřené hvězdokupy a OB asociace. Fárník, F., S. Fischer, L. Sehnal, and B. Valníček. Historie kosmického výzkumu. Perek, L., V. Bumba, J. Kleczek, Z. Švestka, J. Palouš, L. Sehnal, and M. Burša. Mezinárodní organizace. Harmanec, P. BAC. Havlíček, K., P. Ambrož, J. Boček, and F. Žďárský. Vývojové dílny v Ondřejově. Kleczek, J., and M. Páleník. Sluneční energie. Kleczek, J. Řeč astronomů. Řezba, P. Výpočetní středisko ASÚ.—Současnost. Heinzel, P., M. Karlický, and F. Fárník. Sluneční fyzika. Hubený, I. Teoretická hvězdná spektroskopie v Ondřejově. Harmanec, P. Stelární oddělení. Spurný, P., J. Borovička, P. Pravec, and M. Šimek. Meziplanetární hmota. Vandas, M., R. Peřestý, and J. Klokočník. Fyzika okolí Země. Šidlichovský, M., and J. Vondrák. Dynamika sluneční soustavy. Palouš, J. Dynamika Galaxií. Hudec, R., and P. Hadrava. Astrofyzika vysokých energií.

Orchiston, Wayne. Nautical astronomy in New Zealand: the voyages of James Cook. Wellington, N.Z., Carter Observatory, 1998. 131 p. illus., maps, ports. (Occasional papers, no. 1)

Contents: Acknowledgements.—Moore, P. Foreword.—ch. 1. Introduction.—ch. 2. The astronomers.—ch. 3. The astronomical instruments and equipment.—ch. 4. The astronomical observations.—ch. 5. Cook voyage astronomy in historic perspective.—ch. 6. Conclusion.

Reisinger, Reiner. Historische Horoskopie. Das iudicium magnum des Johannes Carion für Albrecht Dürers Patenkind. Mit einem Geleitwort von Dieter Wuttke. Wiesbaden, Harrassowitz, 1997. 339 p. illus., facsims., ports. (Gratia, Bamberger Schriften zum Renaissanceforschung, 32)

Rozenfel'd, Boris A., *and* Nadezhda D. Sergeeva. Akhmad al-Fergani, IX vek. Otv. redaktor, M. M. Rozhanskaia. Moskva, "Nauka," 1998. 85 p. illus. (Seriiă "Nauchno-biograficheskaiă literatura")

Contents: 1. Ot Fergany do Kaira.—2. Zhizn' i trudy.—3. Matematika.—4. Astronomiiă.—5. Astronomicheskie instrumenty.—6. Khronologiiă.—7. Geografiiă.—8. Vliiănie "Ėlementov astronomii" al-Fergani na dal'neĭshee razvitie nauki.

Russo, Lucio. La rivoluzione dimenticata; il pensiero scientifico greco e la scienza moderna. Prefazione di Marcello Cini. Milano, Feltrinelli, 1996. 380 p. illus. (Campi del sapere)

Argues that much of modern western science developed from rediscovery of the science of ancient Greece, which had been neglected and lost during the centuries of Roman domination. Astronomy is among the many topics treated.

Schaldach, Karlheinz. Römische Sonnenuhren; eine Einführung in die antike Gnomonik. Thun, H. Deutsch, 1997. 123 p. illus., map.

Contents: 1. Grundlagen.—2. Zur Geschichte.—3. Sonnenuhrentypen.—4. Zur Analyse.—5. Beispiele.

Turner, Gerard L'E. Scientific instruments, 1500–1900; an introduction. Berkeley, Calif., University of California Press, 1998. 144 p. illus. (part col.)

First published as *Antique Scientific Instruments* in Poole by Blandford Press in 1980.

See particularly "Astronomy and Time-Telling" (p. 11–28) and "Navigational Instruments" (p. 29–37). Telescopes are discussed on p. 98–100 in the section entitled "Optical Instruments."

The Universe unfolding. Edited by Sir Hermann Bondi and Miranda Weston-Smith. Oxford, Clarendon Press, 1998. 406 p., [4] p. of plates. illus. (part col.), facsims., ports.

The Milne Lectures, 1977–96.

Contents: Kington, B. Foreword.—Milne lecturers.—Bondi, Sir H. Introduction.—Hoyle, Sir F. Comets: a matter of life and death (1977).—Lyttleton, R. A. Gravitation, ancient eclipses, and mountains (1978).—Chandrasekhar, S. E. A. Milne: his part in the development of modern astrophysics (1979).—Rees, Sir M. Our universe and others (1980).—Cowling, T. G. Astrology, religion and science (1981).—Wolfendale, Sir A. The origin of cosmic rays (1982).—Kendall, D. G. Statistics, geometry and the cosmos 1983).—King-Hele, D. G. The earth's atmosphere ideas old and new (1984).—McCrea, Sir W. Time, vacuum and cosmos (1985).—Fowler, W. A. The age of the observable universe (1986).—Atiyah, Sir M. Geometry, topology and physics (1987). —Radhakrishnan, V. Polarization—its message in astronomy (1988).—Gold, T. Carbon—the element of life: what is its origin on earth? (1989).—Sciama, D. Cosmology and particle physics: a new synthesis (1990).—Dyson, F. J. Hunting for comets and planets (1991).—Longair, M. S. Modern cosmology—a critical assessment (1992).—Taylor, J. H. Binary pulsars and relativistic gravity (1993).—Kirshner, R. P. Taking the measure of the universe (1994).—Mather, J. C. Observing the Big Bang (1995).—Penrose, Sir R. The complexity of our singular universe (1996).

Western humanistic culture presented to China by Jesuit missionaries (XVII–XVIII centuries). Proceedings of the conference held in Rome, October 25–27, 1993. Edited by Federico Masini. Rome, Institutum Historicum S.I., 1996. 396 p. illus., facsims. (Bibliotheca Instituti Historici S.I., v. 49)

Partial contents: Iannaccone, I. From N. Longobardo's explanation of earthquakes as divine punishment to F. Verbiest's systematic instrumental observations. The evolution of European science in China in the seventeenth century.—Jami, C. From Clavius to Pardies: the geometry transmitted to China by Jesuits (1607–1723).—Libbrecht, U. What kind of science did the Jesuits bring to China?—Moortgat, G. Substance versus function (*ti* vs. *yong*). The humanistic relevance of Yang Guangxian's objection to Western astronomy.—Witek, J. W. A dialogue on astronomical phenomena and natural theology in early eighteenth-century China.

William, *of Conches*. A dialogue on natural philosophy (*Dragmaticon philosophiae*). Translation of the new Latin critical text, with a short introduction and explanatory notes, by Italo Ronca and Matthew Curr. Notre Dame, Ind., University of Notre Dame Press, 1997. xxvi, 212 p. illus. (Notre Dame texts in medievcal culture, v. 2)

See particularly books 3 and 4, which deal with the creation of the stars, their movement, the heavenly circles, the planets and their motion, including retrograde motion and standstill, the seasons, and eclipses of the sun and moon.

York, Derek. In search of lost time. Bristol, Philadelphia, Institute of Physics Pub., 1997. 141 p. illus.

Articles, Including Essays in Books and Papers in Proceedings

Abraham, George. Ancient and medieval star catalogues. Indian journal of history of science, v. 32, Mar. 1997: 47–51.

Abraham, George. Variable radius epicycle model. Indian journal of history of science, v. 32, June 1997: 135–138. illus.

Achar, B. N. Narahari. Enigma of the five-year yuga of Vedāṇga Jyotia. Indian journal of history of science, v. 33, June 1998: 101–109.

Alexander, Amir. Lunar maps and coastal outlines: Thomas Hariot's mapping of the moon. Studies in history and philosophy of science, v. 29A, Sept. 1998: 345–368. illus., maps.

Andrews, Arthur D. The Boyden Observatory. Irish astronomical journal, v. 25, July 1998: 129–166. illus., ports.

A short history of the Boyden Observatory, Bloemfontein, "is followed by a personal account of life and work at Boyden in 1965–1967 ..."

Ansari, S. M. Razaullah. Ghulām usain Jaunpūrī and his Zīj-i Bahādurkhānī. Studies in history of medicine and science, v. 14, no. 1/2, 1995/96: 181–188.

The zīj was compiled in 1838.

Ashworth, William J. John Herschel, George Airy, and the roaming eye of the state. History of science, v. 36, June 1998: 151–178.

Astronomia e letteratura. Giornale di astronomia, v. 24, mar. 1998: 20–39. illus. (part col.), facsims., ports. (part col.)

Contents: Barletti, R. Regalare Dante partendo dall'astronomia.—Usher, P. D. La visione del cosmo di William Shakespeare.—Vetrano, F. Storia enigmatica di un universo: il tempo personale di Giacomo Leopardi tra il nulla e l'eternità.—Gabici, F. "io lo so perché tanto di stelle ..." L'astronomia nei versi di Giovanni Pascoli.

Usher's paper was originally published as "Shakespeare's Cosmic World View" in *Mercury*, v. 26, Jan./Feb. 1997, p. 20–23.

Aubourg, Éric. La date de conception du zodiaque du temple d'Hathor à Dendera. *In* Cairo. Institut français d'archéologie orientale. Bulletin. t. 95. Le Caire, 1995. p. 1-10. illus. (part col.)

English summary: p. 647.

Banfi, Vittorio. L'origine e la formazione delle comete secondo R. A. Lyttleton. Giornale di astronomia, v. 24, mar. 1998: 40–47. illus.

Barocas, Vinicio. The Preston Observatory. 1. The first fifty years. Southern stars, v. 37, June 1998: 237–243.

The observatory was founded in Preston, Lancs., in 1881.

Beeson, David. Hesitating on the threshold: Maupertuis's apprenticeship as a Newtonian. *In* International Congress on the Enlightenment, *8th, Bristol, 1991*. Transactions of the Eighth International Congress on the Enlightenment. 2. Oxford, Voltaire Foundataion at the Taylor Institution, 1992. (Studies on Voltaire and the eighteenth century, 304) p. 1118–1121.

Belmonte Avilés, Juan A., César Esteban López, *and* José Jiménez González. Mediterranean archaeoastronomy and archaeotopography: pre-Roman tombs of Africa Proconsularis. *In* Archaeoastronomy. no. 23; 1998. Cambridge, Science History Publications. p. S7–S24. illus., map.

Bender, Daryl. A proposal for the eclipse mechanism on the Wallingford clock. Antiquarian horology, v. 24, autumn 1998: 217–224. illus.

Bender, Daryl. A proposal for the striking mechanism on the Wallingford clock. Antiquarian horology, v. 24, summer 1998: 134–140. illus.

Richard of Wallingford (1291–1336), abbot of the Benedictine monastery at St. Albans, "began work on this large monumental astronomical clock. While predating de Dondi's work it nevertheless had more accurate astronomical gearing. Unfortunately the clock was lost some time after the middle of the sixteenth century ..." Through Richard's surviving manuscripts, however, "we gain an appreciation of this very early yet incredibly complex timepiece."

Bernard, Étienne A. Pensée scientifique et pensée magique: le cas de l'astronomie et de l'astrologie. Ciel et terre, v. 114, mai/juin 1998: 104–112. illus.

Blitzstein, William. The seven identified observations of Uranus made by John Flamsteed using his mural arc. Observatory, v. 118, Aug. 1998: 219–222.

Böhm, Conrad. Luna III: inizia l'esplorazione planetaria. L'Astronomia, anno 20, luglio 1998: 58–59. illus. (part col.) (Osservatorio del passato)

On the results obtained by a Soviet spacecraft that traveled to the moon in October 1959.

Böhnhardt, Hermann. In memoriam Professor Vladímir Vanýsek, editor-in-chief of Earth, Moon, and Planets. Earth, moon, and planets, v. 76, no. 1/2, 1997/98: 1–3. port.

Boiy, Tom. BM 59748, 28.XIIa.43 S.E.: an exception to the Babylonian intercalary cycle? N.A.B.U., Nouvelles assyriologiques brèves et utilitaires, mars 1998: 6–7.
Bondi, *Sir* Hermann. Raymond Arthur Lyttleton, 7 May 1911–16 May 1995. *In* Royal Society of London. Biographical memoirs of Fellows. v. 43; 1997. London. p. 303–219. port.
Bone, Neil. The 1799 Leonids. *In* British Astronomical Association, *London*. Journal, v. 108, Aug. 1998: 230. illus.
Boxmeer, Henri van. Poussières d'archives ... Les méridiennes de Quetelet (suite et fin). Le pavillon astronomique de Liège. Les méridiennes de Louvain, de Lierre, d'Alost et de Termonde. Ciel et terre, v. 114, janv./fév. 1998: 33–36. illus., facsim.
Brown, Robert Hanbury. R V Jones 1911-1997. Astronomy & geophysics, v. 39, Aug. 1998: 438. port.
Calvo Labarta, Emilia. Astronomical theories related to the sun in Ibn a-Hā'im's al-Zīj al-Kamil fī'l-Ta'ālīm. *In* Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften. Bd. 12. Frankfurt am Main, Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 1998. p. 51–111. illus.
Includes Arabic text of extracts from the zīj.
Chapman, Allan. James Nasmyth: astronomer of fire. *In* Yearbook of astronomy. 1997. Edited by Patrick Moore. London, Macmillan, 1996. p. 143–167. facsims., port.
Chapman, David M. F. 140 years of comet photography. *In* Royal Astronomical Society of Canada. Journal, v. 92, Aug. 1998: 186–187. (Reflections)
Chatterjee, S. K. Balinese traditional calendar. Indian journal of history of science, v. 32, Dec. 1997: 325–346.
A folded table designated "Appendix A," showing the Pawukon 210-day calendar, follows p. 346.
Chatterjee, S. K. A note on Kali era. Indian journal of history of science, v. 32, Mar. 1997: 69–86.
Chatterjee, S. K. Traditional calendar of Myanmar (Burma). Indian journal of history of science, v. 33, June 1998: 143–160. illus.
Chinnici, Ileana. An "Italian" observatory in India: the history of the Calcutta Observatory. Studies in history of medicine and science, v. 14, no. 1/2, 1995/96: 91–115. illus., ports.
Cohen, I. Bernard. Newton's determination of the masses and densities of the sun, Jupiter, Saturn, and the earth. Archive for history of exact sciences, v. 53, no. 1, 1998: 83–95. illus.
Coles, Peter. David Norman Schramm (1945–97). Observatory, v. 118, Aug. 1998: 251–252.
Creese, Mary R. S. Elizabeth Brown (1830–1899), solar astronomer. *In* British Astronomical Association, *London*. Journal, v. 108, Aug. 1998: 193–197. facsim., port.
Crépel, Pierre. Gilbert Romme et les mathématiques. Annales historiques de la Révolution française, no 304, avril/juin 1996: 107–220.
Davis, Dale, *and* Charles Standard. Celestial phenomena in Lacandon Maya song and lore. *In* Latin American Indian Literatures Association. Symposium, *12th, Universidad Nacional Autónoma de México, 1995.* Messages and meanings; papers from the Twelfth Annual Symposium, Latin American Indian Literatures Association/Asociación de Literaturas Indígenas Latinoamericanas. Edited by Mary H. Preuss. Lancaster, Calif., Labyrinthos, 1997. p. 47–51.
Débarbat, Suzanne V. À la rencontre de Christiaan Huygens. L'Astronomie, v. 112, avril/mai 1998: 148–151. illus.
On learning more about Huygens in the museum at his home, Hofwijck, and the Boerhaave Museum in Leiden.
Deiss, Bruno M., *and* Volker Nebel. On a pretended observation of Saturn by Galileo. Journal for the history of astronomy, v. 29, Aug. 1998: 215–220. illus.
Dejaiffe, René. Odon Godart [1913–1996] et son oeuvre. Ciel et terre, v. 114, juil./août 1998: 143–148.
Delsemme, Armand H. Recollections of a cometary scientist. Planetary and space science, v. 46, Jan. 1998: 111–124. illus., group ports.
The group portraits were taken at the 4th and 5th international colloquia of astrophysics, held at Liege in 1952 and 1965.

Depuydt, Leo. The time of death of Alexander the Great: 11 June 323 B.C. (-322), ca. 4:00–5:00 PM. *In* Die Welt des Orients. Bd. 28; 1997. Göttingen, Vandenhoeck & Ruprecht, 1998. p. 117–135.

Examines the differing dates given in ancient sources and the workings of the calendars used—Babylonian, Egyptian, and Macedonian.

Dick, Steven J., Wayne Orchiston, *and* Tom Love. Simon Newcomb, William Harkness and the nineteenth century American transit of Venus expeditions. Journal for the history of astronomy, v. 29, Aug. 1998: 221–255. illus., map, ports.

Dobson, Geoffrey J. Newton's problems with rigid body dynamics in the light of his treatment of the precession of the equinoxes. Archive for history of exact sciences, v. 53, no. 2, 1998: 125–145. illus.

Dollar, Tom. In the realm of the long eyes. Arizona highways, v. 74, Aug. 1998: 4–11. col. illus.

A "tour of the telescope sites open to the public" in Flagstaff and on Kitt Peak, Mount Hopkins, and Mount Graham, as well as Discovery Park in Safford. The astronomy camps at Mount Lemmon are also mentioned.

Dollfus, Audouin. Les frères Huygens et les grandes lunettes sans tuyau. L'Astronomie, v. 112, avril/mai 1998: 114–129. facsims.

Dollo, Corrado. L'incorruttibilità dei cieli nelle *Reportationes* di Gerolamo [Hieronymus] Piccolomini (1612). *In* Sicvlorvm gymnasivm. nuova ser., anno 46; 1993. Catania, Tip. E. Leone, 1994. p. 577–603.

Includes Latin text of "Quaestio tertia De Accidentibus coeli" from Piccolomini's In octo libros Physicorum Aristotelis Adnotationes et quaestiones.

Douglas, Geoffrey G., Thomas E. Corbin, *and* Brian D. Mason. Charles Edmund Worley (1935–97). Observatory, v. 118, Aug. 1998: 250–251.

Douglas, Graham. Color-term connotations, planetary personalities, and Greimas's square. Semiotica, v. 115, 3/4, 1997: 263–287. illus.

Douglas, Graham. Greimas's semiotic square and Greek and Roman astrology. Semiotica, v. 114, 1/2, 1997: 1–19. illus.

Ducos, Joëlle. Le clerc et les météores: constitution et évolution d'une culture encyclopédique. *In* Le Clerc au Moyen Age. Aix-en-Provence, CUER MA, Université de Provence (Centre d'Aix), 1995. (Sénéfiance, no 37) p. 149–164.

Dunn, Francis M. The uses of time in fifth-century Athens. Ancient world, v. 29, no. 1, 1998: 37–52. illus.

Ernst, Germana. Il cielo in una stanza. L'*Apologeticus* di Campanella in difesa dell'opuscolo *De siderali fato vitando*. Bruniana & Campanelliana, anno 3, n. 2, 1997: 303–304.

The Latin text of the *Apologeticus* has Italian translation on facing pages (p. 314–331). An English summary of the introductory essay appears on p. 303.

Etayo-Piñol, Marie A. Medina y Cortés; o, El aprendizaje de las técnicas de navegación en Europa en el siglo XVI. Según la edición lyonesa. Revista de historia naval, año 16, 2. trimestre 1998: 41–47. col. ports.

Fanti, Roberto. Sessant'anni di radioastronomia: la scoperta di un universo invisibile. Il Nuovo saggiatore, nuova ser., anno 9, mar./apr. 1993: 27–41; magg./ag.: 48–58. illus. (part col.), maps (part col.) (Scienza in primo piano)

Faracovi, Ornella. Sull'oroscopo di Campanella. Bruniana & Campanelliana, anno 3, n. 2, 1997: 245–263. facsims.

Summary in English.

Fernie, J. Donald. Transits, travels and tribulations. 4. American scientist, v. 86, Sept./Oct. 1998: 422–425. illus., facsims.

On the 1769 expeditions of Chappe d'Auteroche and William Wales.

Ferrari d'Occhieppo, Konradin. Neue Argumente zu Aufgang und Stillstand des Sterns in der Magierperikope Matthäus 2, 1–12. *In* Österreichische Akademie der Wissenschaften. *Mathematisch-naturwissenschaftliche Klasse*. Sitzungsberichte. Abt. II. 206. Bd.; Jahrg. 1997. Wien, Verlag der Österreichischen Akademie der Wissenschaften, 1998. p. 317–344.

Fowler, David. In memoriam: Wilbur Richard Knorr (1945–1997), an appreciation. Historia mathematica, v. 25, May 1998: 123–132. port.

The portrait faces p. 123.

Frand, Pascal. Le calendrier républicain dans les annuaires datés de l'an IV à l'an XIII. Annales historiques de la Révolution française, no 298, oct./déc. 1994: 671–686. facsims.

Abstract in English: p. 779.

Fritz, John M., *and* J. McKim Malville. Recent archaeo-astronomical research at Vijayanagara. *In* Association of South Asian Archæologists in Western Europe. International Conference, *11th, Berlin, 1991.* South Asian archæology 1991. Proceedings of the eleventh International Conference of the Association of South Asian Archæologists in Western Europe, held in Berlin 1–5 July 1991. Edited by Adalbert J. Gail and Gerd J. R. Mevissen, with the assistance of Britta Zehmke. Stuttgart, F. Steiner, 1993. p. 415–425. maps, plans.

Fritz, Manfred, Ludwig Oechslin, Jörg Spöring, *and* Franz Türler. Der Himmel auf Erden. Die Türler-Uhr in Zürich: ein Modell des Kosmos. Kultur & Technik, 21. Jahrg., Nr. 3, 1997: 46–50. illus. (part col.)

A modern astronomical clock that took nine years to build.

Froeschlé, Michel. À propos du calendrier républicain: Romme et l'astronomie. Annales historiques de la Révolution française, no 304, avril/juin 1996: 303–325.

Fuller, Dudley K. M. The recovery of a long forgotten, early 18th century 6″ Newtonian reflector—a remarkable story. Journal of the Antique Telescope Society, v. 11, summer 1996: 12–13. illus.

Galea, Adrian J. On the trail of the nature of shooting stars; Maltese observations of the meteor displays of November 27, 1872 and 1885. *In* Malta year book. 1996. Sliema, Malta, De La Salle Brothers Publications. p. 471–476.

Garzoni, Tomaso. Discorso XXXIX. Degli astronomi e astrologi. *In his* La piazza universale di tutte le professioni del mondo. A cura di Paolo Cherchi e Beatrice Collina. v. 1. Torino, G. Einaudi editore, 1996. p. 604–639.

See also Discorso VI, "De' formatori de' klendari" (v. 1, p. 187–205), and Discorso LXXX, "De' maestri d'orologi" (v. 2, p. 996–1000).

Garzoni's work was first published in 1585.

Gaspani, Adriano. Cosa vide Gan De? L'Astronomia, anno 20, giugno 1998: 36–43. col. illus. (Ottica)

Could Gan De, observing in the fourth century B.C., have seen a satellite of Jupiter?

Includes a box, "Cosa vide veramente Gan De?" (p. 41).

Gatti, Hilary. Giordano Bruno's *Ash Wednesday Supper* and Galileo's *Dialogue of the Two Major World Systems*. Bruniana & Campanelliana, anno 3, n. 2, 1997: 283–300.

Summary in English.

Gingerich, Owen. In retrospect: *De revolutionibus orbium celestium* ("On the revolutions of the heavenly spheres") by Nicolaus Copernicus (1543). Nature, v. 391, Jan. 8, 1998: 340. facsims.

Golvers, Noël. Ferdinand Verbiest's *Compendium Latinum* (Peking, 1678), with a census. Quaerendo, v. 28, spring 1998: 85–127. facsims., port.

"Appendix: Preliminary 'census' (30 August 1997)": p. 117–127.

González González, Francisco J. Pendulos astronómicos y cronómetros marinos de la Armada: el Observatorio de San Fernando y los antecedentes del patrón nacional de tiempo (1753–1957). Asclepio, v. 50, fasc. 1, 1998: 175–198.

Summary in English.

Gossin, Pamela. "All Danaë to the stars": nineteenth-century representations of women in the cosmos. Victorian studies, v. 40, autumn 1996: 65–96.

Graf-Stuhlhofer, Franz. Zu den Hofastronomen Kaiser Maximilians. Über das jahrzentelange Fortwirken historischer Irrtümer. Bibliothèque d'humanisme et renaissance, t. 60, juin 1998: 413–419.

Granada, Miguel A. Cálculos cronológicos, novedades cosmológicas y expectativas escatológicas en el Europa del siglo XVI. *In* Rinascimento, rivista dell'Istituto nazionale di studi sul Rinascimento. 2. serie, v. 37. Firenze, L. S. Olschki, 1997. p. 357–435.

Grant, Edward. In memoriam: Richard S. Westfall, 1924–1996. Archives internationales d'histoire des sciences, v. 47, déc. 1997: 389–392.

Griffin, Rita Elizabeth M. The Mount Wilson 100-inch—America's 'vintage' large telescope. Journal of the Antique Telescope Society, v. 11, summer 1996: 14–19. illus.

Griffin, Roger F. O. C. Wilson and his *K*-line intensities. Observatory, v. 118, June 1998: 145–153.

Refutes criticisms of Wilson's estimates.

Gurshten, Aleksandr A. The evolution of the zodiac in the context of ancient oriental history. Vistas in astronomy, v. 41, pt. 4, 1997: 507–525. illus., facsim.

Habison, Peter. Die Sternwarte des Bierbrauers Moriz von Kuffner in Wien. Sterne und Weltraum, 37. Jahrg., Nr. 5, 1998: 477–480. illus. (part col.), port.

"Am Gallitzinberg in Wien-Ottakring, einem der östlichen Ausläufer des Wienerwaldes, befindet sich eine Sternwarte aus der Zeit des Historismus. Sie gehörte einst einem Grossindustriellen der österreichisch-ungarischen Monarchie und hat sich bis heute ihr historisches Aussehen bewahrt. In den letzten Jahren wurde sie renoviert und als astronomisches Bildungsinstitut neu adaptiert. Eine Geschichte des Observatoriums, seines Gründers und seiner Astronomen von der Jahrhundertwende bis zur Gegenwart."

Hahn, Roger. A scientist responds to his skeptical crisis: Laplace's philosophy of science. *In* The Skeptical tradition around 1800; skepticism in philosophy, science, and society. Edited by Johan van der Zande and Richard H. Popkin. Dordrecht, Boston, Kluwer Academic Publishers, 1998. (Archives internationales d'histoire des idées, 155) p. 187–201.

Hallyn, Fernand. La préface de Gemma Frisius aux *Ephemerides* de Stadius (1556). Scientiarum historia, jaarg. 24, nr. 1, 1998: 3–15. ports.

Hari, K. Chandra. True rationale of Sūrya Siddhānta. Indian journal of history of science, v. 32, Sept. 1997: 183–190.

Heine, Elizabeth. W. B. Yeats: poet and astrologer. Culture and cosmos, v. 1, autumn/winter 1997: 60–75. facsim.

Hennessey, R. A. S. Charles Pritchard [1808–1893] Astronomy now, v. 12, July 1998: 19–20. illus., port.

"The Reverend Dr Charles Pritchard, a Victorian amateur astronomer, became Savilian Professor of Astronomy at Oxford when he was 62."

Hilton, James L., *and* P. Kenneth Seidelmann. An examination of the change in the earth's rotation rate from ancient Chinese observations of lunar occultations of the planets. Astronomical journal, v. 104, Dec. 1992: 2250–2252.

Hintsches, Eugen. Einsteins Phantom. Kultur & Technik, 21. Jahrg., Nr. 2, 1997: 36–37. illus.

"Die Gravitationslinsen, die Einstein 1912 berechnet hatte, schienen ihm damals unglaubwürdig."

Holberton, Paul. Notes on Giulio Campagnola's prints. Print quarterly, v. 13, Dec. 1996: 397–400. illus.

Focuses on two engravings—"Saturn" and the "Astrologer."

Holmes, Nigel. Lucan 7, 425: planets or stars? Mnemosyne, v. 51, Aug. 1998: 446–449.

Hoppmann, Jürgen G. H. The Lichtenberger prophecy and Melanchthon's horoscope for Luther. Culture and cosmos, v. 1, autumn/winter 1997: 49–59. facsims.

Hoskin, Michael A., *and others*. Studies in Iberian archaeoastronomy. 5. Orientations of megalithic tombs of northern and western Iberia. *In* Archaeoastronomy. no. 23; 1998. Cambridge, Science History Publications. p. S39–S87. illus., map.

Fifteen reports produced with a number of collaborators.

Hübner, Wolfgang. Die Lyra cosmica des Eratosthenes: das neunte Sternbild der Musen mit neun Sternen und neun Saiten. Museum helveticum, v. 55, Juni 1998: 84–111.

Hüttig, Manfred. The conical sundial from Abû Mîna. A second analysis. *In* Société d'archéologie copte. Bulletin. t. 37; 1998. Le Caire. p. 135–141. illus.

Iwaniszewski, Stanisław. Entre el pasado y el presente: varios conceptos del tiempo y la tensión cronotípica entre los mexicas según las fuentes del siglo XVI. *In* Latin American Indian

Literatures Association. Symposium, *12th, Universidad Nacional Autónoma de México, 1995.* Messages and meanings; papers from the Twelfth Annual Symposium, Latin American Indian Literatures Association/Asociación de Literaturas Indígenas Latinoamericanas. Edited by Mary H. Preuss. Lancaster, Calif., Labyrinthos, 1997. p. 115–127.

Iwanowska, Wilhelmina. Od Kopernika do Wolszczana: historia odkryći i współczesne badania astronomiczne wszechświata. Analecta, r. 6, nr. 1, 1997: 311–320. illus.

English summary.

Jáchim, František. Astronomie v díle Tadeáše Hájka z Hájku. DVT, Dějiny věd a techniky, roč. 30, čís. 4, 1997: 211–235.

English summary.

Jager, Cornelis de. In memoriam: Hans van Diggelen. Zenit, 25. jaarg., sept. 1998: 365.

Jarrell, Richard A. King, William Frederick. Surveyor, astronomer, and civil servant. *In* Dictionary of Canadian biography. v. 14. 1911 to 1920. Toronto, Buffalo, University of Toronto Press, 1998. p. 558–559.

Johnson, Kevin. "The Sun Spotteries"—the South Kensington Solar Physics Observatory, 1879–1913. Journal of the Antique Telescope Society, issue 15, summer 1998: 22–24.

Jordi, C., Leslie V. Morrison, Richard D. Rosen, David A. Salstein, *and* G. Rosselló. Fluctuations in the Earth's rotation since 1830 from high-resolution astronomical data. Geophysical journal international, v. 117, June 1994: 811–818. illus.

Jospe, Raphael. The Torah and astrology according to Abraham ibn Ezra. *In* World Congress of Jewish Studies, *11th, Jerusalem, 1993.* Proceedings of the Eleventh World Congress of Jewish Studies, Jerusalem, June 22–29, 1993. Division C. Thought and literature. v. 2. Jewish thought, Kabbalah and Hasidism. Jerusalem, World Union of Jewish Studies, 1994. p. 17–24.

Junod, Philippe. Variations modernes sur un thème: la musique des sphères. *In* Research Center for Musical Iconography. RIdIM newsletter, v. 22, fall 1997: 53–61. illus., facsims.

Kagan, Boris A., *and* Jürgen Sündermann. Dissipation of tidal energy, paleotides, and evolution of the earth-moon system. *In* Advances in geophysics. v. 38. Edited by Renata Dmowska, Barry Saltzman. San Diego, Academic Press, 1996. p. 179–266. illus.

Kak, Subhash C. Early theories on the distance to the sun. Indian journal of history of science, v. 33, June 1998: 93–100. illus.

Kak, Subhash C. Sāyaṇa's astronomy. Indian journal of history of science, v. 33, Mar. 1998: 31–36.

Kammerer, Odile. Un prodige en Alsace à la fin du XV[e] siècle: la météorite d'Ensisheim. *In* Congrès de la Société des historiens médiévistes de l'enseignement supérieur public, *25th, Orléans, 1994.* Miracles, prodiges et merveilles au Moyen Âge. XXV[e] Congrès de la S.H.M.E.S. (Orléans, juin 1994). Paris, Publications de la Sorbonne, 1995. (Série Histoire ancienne et médiévale, 34) p. 293–315. facsims.

Kemp, Martin. Modelled moons. Nature, v. 394, Aug. 27, 1998: 837. illus.

"How do you bring a flat picture to three-dimensional life? Early photographers met the same visual challenges that confronted Galileo. They used ingenious methods to build relief models of the lunar landscapes."

Kilburn, Kevin J., Michael Oates, *and* Anthony W. Cross. The ghost book of Manchester. Sky & telescope, v. 96, Nov. 1998: 83–86. facsims., col. group port. (Amateur astronomers)

On the discovery, in the collections of the Manchester Astronomical Society, of John Bevis's *Atlas celeste*.

Includes a box, "Prediscovery Observations of Uranus" (p. 86).

Kollerstrom, Nick. The star zodiac of antiquity. Culture and cosmos, v. 1, autumn/winter 1997: 5–22. illus.

Korpikiewicz, Honorata. In memoriam. Bohdan Kiełczewski (1912–1998). Urania—postępy astronomii, t. 69, maj/czerw. 1998: 134–135.

Kozhamthadam, Job. Kepler and the origin of modern science. Indian journal of history of science, v. 33, Mar. 1998: 63–86.

Kruk, Jacek. Lucjan Orkisz (1899–1973). Urania—postępy astronomii, t. 69, stycz./luty 1998: 36–37. illus., port. (Z historii polskiej astronomii)

Krupp, Edwin C. Moonlit highways. Sky & telescope, v. 96, Sept. 1998: 94–96. col. illus. (Rambling through the skies)

Mostly about Harran, "renowned for at least three millenniums as a sacred city of Sin, the Mesopotamian moon god, and as the home of one of his most important temples."

Künzl, Ernst. Der Globus im Römisch-Germanischen Zentralmuseum Mainz: der bisher einzige komplette Himmelsglobus aus dem griechisch-römischen Altertum. *In* Der Globusfreund. Nr. 45/46; 1997/98. Wien, Internationale Coronelli-Gesellschaft für Globen- und Instrumentenkunde, 1998. p. 7–80. illus. (part col.)

Contents: Herkunft und Fundumstände.—Technik, Stil und Datierung.—Ein Obelisk als Gnomon einer Sonnenuhr.—Zodiacus und Sternzeichen bei der Hemisphären.—Ikonographie der Sternzeichen.—Astronomie.—Die Milchstrasse.—Himmelsgloben und Planisphären.

Fifteen illustrations appear on plates bound at the end of the volume. Additional color illustrations are reproduced on the outside front and back covers of the issue.

A full English translation, "The Globe in the 'Römisch-Germanisches Zentralmuseum Mainz'—the Only Complete Celestial Globe Found to-Date From Classical Greco-Roman Antiquity," appears on p. 81–153.

Kunitzsch, Paul. Traces of a tenth-century Spanish-Arabic astrolabe. *In* Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften. Bd. 12. Frankfurt am Main, Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 1998. p. 113–120. illus.

Kurtik, Gennadiĭ E. Astral'naiâ simbolika v Mesopotamii III tys. do n.ė. Voprosy istorii estestvoznaniiâ i tekhniki, no. 2, 1998: 20–44. illus. (Iz istorii estestvoznaniiâ)

Abstract in English: p. [204]

Laird, Edgar S. Christine de Pizan and controversy concerning star-study in the court of Charles V. Culture and cosmos, v. 1, autumn/winter 1997: 35–48.

Lange, Armin. The Essene position on magic and divination. *In* International Organization for Qumran Studies. Meeting, *2d, Cambridge, 1995.* Legal texts and legal issues. Proceedings of the second Meeting of the International Organization for Qumran Studies, Cambridge, 1995. Published in honour of Joseph M. Baumgarten. Edited by Moshe Bernstein, Florentino García Martínez, John Kampen. Leiden, New York, Brill, 1997. (Studies on the texts of the desert of Judah, v. 23) p. 377–435.

Astrological approaches to divination are among those considered.

Laviolette, Jean G. Du quadrant au cadran de hauteur. Chronometrophilia, no 44, été 1998: 27–40. illus.

Lepage, Thierry. La lune rousse dans la parémiologie* française. Ciel et terre, v. 114, juil./août 1998: 136–139.

"(*) Terme d'origine grecque obtenu à partir des termes paroimia signifiant 'proverb, dicton' et logos signifiant 'discours, étude scientifique.'"

Le Prado-Madaule, Danielle. L'astrométéorologie: influence et évolution en France 1520–1640. Histoire, économie et société, 15. année, avril/juin 1996: 179–201.

On the application of astrology to weather-forecasting.

Abstract in English.

Li, Y., *and* C. Z. Zhang. Chinese models of solar and lunar motions in the 13th century. Astronomy and astrophysics, v. 333, May (I) 1998: L13–L15. illus.

Li, Y., *and* C. Z. Zhang. Chinese syzygy calculations established in the 13th century. Astronomy and astrophysics, v. 332, Apr. (III) 1998: 1142–1146. illus.

Li, Y., *and* C. Z. Zhang. Secular variation of earth's rotation: inferred from the Chinese ancient *Shoushi* calendar (AD 1281). Earth, moon, and planets, v. 76, no. 1/2, 1997/98: 11–17. illus.

Lichtenberg, Heiner, Leonard Gerhards, Alfons Grassl, *and* Heinz Zemanek. Die Struktur des Gregorianischen Kalenders. Sterne und Weltraum, 37. Jahrg., Nr. 4, 1998: 326–332.

"In diesem Aufsatz wird dargelegt, was am Gregorianischen Kalender zeitlos und was zeitabhängig ist. Die wird durch Verallgemeinerung der Gaussschen Osterformel erreicht. Erst eine verallgemeinerte Gausssche Osterformel lässt beides, den invarianten Kern und die Flexibilität dieses vorzüglichen und mit Recht heute weltweit verbreiteten Zeitrechnungssystems, klar zum Vorschein kommen."

Liu, Baolin, *and* F. Richard Stephenson. A brief contemporary history of the Chinese calendar. Orion, 56. Jahrg., Aug. 1998: 33–36. illus.

Liu, Baolin, *and* F. Richard Stephenson. The Chinese calendar and its operational rules. Orion, 56. Jahrg., Juni 1998: 16–20. illus.

"The Chinese calendar is a form of lunisolar calendar. The rules in operation today have remained unchanged since almost the very beginning of the last (Qing) dynasty–i.e. as far back as A.D. 1645. Since 1914, Western astronomical theory has been used in calculating the positions of the Sun and Moon (and other relevant details) but the basic rules have been unaffected. It is the purpose of this article to explain these rules, particularly with regard to the determination of month numbers and intercalation. One of the present authors (Liu) has specialised in the study of the Chinese calendar for many years."

Locke, Jack L. The beginning of the Dominion Radio Astrophysical Observatory. *In* Royal Astronomical Society of Canada. Journal, v. 92, June 1998: 112–114. illus., ports.

Followed on p. 114–115 by the text of "Official Opening of the Dominion Radio Astrophysical Observatory, White Lake, Penticton, B.C., June 20, 1960," by G. J. Odgers, first published in the *Journal*, v. 54, Dec. 1960, p. 269–272.

López Borgoñoz, Alfonso. Orientations of graves in the late Roman necropolises of Ampurias. *In* Archaeoastronomy. no. 23; 1998. Cambridge, Science History Publications. p. S25–S30. illus., map.

McCall, Joe. The enigma of tektites. *In* Yearbook of astronomy. 1998. Edited by Patrick Moore. London, Macmillan, 1997. p. 165–186. illus., maps.

MacMinn, Donn. An analysis of Ptolemy's treatment of retrograde motion. Journal for the history of astronomy, v. 29, Aug. 1998: 257–270. illus.

Maddison, Ron. Fifty years, and still the eighth wonder of the world: the Palomar 200-inch reflector. *In* Yearbook of astronomy. 1997. Edited by Patrick Moore. London, Macmillan, 1996. p. 183–197. illus.

Maddison, Ron. The Hale Telescope on Palomar Mountain: a giant leap in design. Journal of the Antique Telescope Society, issue 13, summer 1997: 4–14. illus.

Maeyama, Yasukatsu. Determination of the sun's orbit: Hipparchus, Ptolemy, Al-Battānī, Copernicus, Tycho Brahe. Archive for history of exact sciences, v. 53, no. 1, 1998: 1–49. illus.

Malina, Bruce J. Jesus as astral prophet. Biblical theology bulletin, v. 27, fall 1997: 83–98.

"Jesus' final discourse in the Synoptics is replete with words, phrases and statements typical of ancient Mediterranean astronomy/astrology. Further, forecasts concerning the Son of Man coming from the sky and the destruction of Jerusalem, a temple city, clearly entail astronomical and astrological dimensions. These features point to traditions about Jesus as astral prophet and his concern with sky events, much like Israel's astral prophets and their focus on celestial territoriality."

Marinone, Nino. La costellazione. *In his* Berenice, da Callimaco a Catullo. Testo critico, traduzione e commento. Nuova ed., ristrutturata, ampliata e aggiornata. Bologna, Pàtron editore, 1997. p. 245–259. illus.

Mathur, M. N. Risālah dar 'Ilm-i Hay'at-i Jadīd, a 19th century Persian treatise on modern astronomy. Studies in history of medicine and science, v. 12, no. 1/2, 1993: 89–95.

Maurer, Andreas. A compendium of all known William Herschel telescopes. Journal of the Antique Telescope Society, issue 14, winter 1998: 4–15. illus., map.

Michalec, Adam. Polskie Towarzystwo Astronomiczne ma 75 lat! Urania—postępy astronomii, t. 69, mar./kwiec. 1998: 82–83. illus.

Miziołek, Jerzy. Oculus coeli: osservazioni sulla simbologia della luce nella cappella del primate Uchanius a Lovitium (Łowicz). Qvasar, n. 8/9, luglio 1992/giugno 1993: 5–18. illus., facsims.

Mohr, Paul. A cometary conflagration in the west of Ireland: "Pædæphilus" versus John Birmingham. Irish astronomical journal, v. 25, July 1998: 179–206. illus., facsims., map, ports.

Moran, James M. Thirty years of VLBI: early days, successes, and future. *In* IAU Colloquium, *164th, Socorro, N.M., 1997.* Radio emission from galactic and extragalactic compact sources. Proceedings of IAU Colloquium 164 held in Socorro, New Mexico, USA, 21–26 April 1997. Edited by J. Anton Zensus, G. B. Taylor, and J. M. Wrobel. San Francisco, Astronomical Society of the Pacific, 1998. (Astronomical Society of the Pacific conference series, v. 144) p. 1–10.

Moyer, Albert E. Simon Newcomb: astronomer with an attitude. Scientific American, v. 279, Oct. 1998: 88–93. illus. (part col.), facsim., ports.

"The most celebrated American astronomer of the late 19th century advocated broad social and cultural reforms based on the use of scientific method."

Müller, Paola. Dal geocentrismo all'eliocentrismo: verso una nuova immagine del mondo. *In* Studi umanistici piceni. 13; 1993. Sassoferrato, Istituto internazionale studi piceni. p. 141–150.

Mulligan, Joseph F. Who were Fabry and Pérot? American journal of physics, v. 66, Sept. 1998: 797–802. illus., ports.

Munzar, Jan. Antonín Bečvář—meteorolog. DVT, Dějiny věd a techniky, roč. 30, čís. 1, 1997: 41–44.

Murray, William Breen. Models of temporality in archaeoastronomy and rock art studies. *In* Archaeoastronomy. no. 23; 1998. Cambridge, Science History Publications. p. S1–S6.

Nicolaïdis, Efthymios. Ideology and scholarship in Soviet astronomy. Physis, nuova ser., v. 37, fasc. 3, 1997: 659–674.

Nouhuys, Tabitta van. Copernicus als randverschijnsel. De kometen van 1577 en 1618 en het wereldbeeld in de Nederlanden. Scientiarum historia, jaarg. 24, nr. 1, 1998: 17–38. facsims., ports.

Ōhashi, Yukio. Early history of the astrolabe in India. Indian journal of history of science, v. 32, Sept. 1997: 199–295. illus.

"Special attention is paid to the *Yantra-rāja-adhikāra* of Padmanābha, and its full text with English translation is presented here for the first time."

Olson, Donald W., Marilynn S. Olson, *and* Russell L. Doescher. The stars of Hamlet. Sky & telescope, v. 96, Nov. 1998: 68–73. facsims., map, ports. (Astronomical computing)

"A spectacular celestial event and the Danish astronomer who studied it may have inspired parts of William Shakespeare's famous play."

Orchiston, Wayne. Illuminating incidents in antipodean astronomy: John Tebbutt and the great comet of 1861. Irish astronomical journal, v. 25, July 1998: 167–178. illus., ports.

Oudenot, Gérard. Histoire des planétariums. Comment représenter les étoiles, les planètes et leurs mouvements apparents. *In* La Science en scène. Paris, Presses de l'École normale supérieure et Palais de la découverte, 1996. p. 143–150.

Panaino, Antonio. Saturn, the lord of the seventh millennium. East and West, v. 46, Dec. 1996: 235–250.

Includes a note contributed by David Pingree (p. 239–240).

Pang, Alex Soojung-Kim. Technology, aesthetics, and the development of astrophotography at the Lick Observatory. *In* Inscribing science; scientific texts and the materiality of communication. Edited by Timothy Lenoir. Stanford, Calif., Stanford University Press, 1998. (Writing science) p. 223–248.

Pingree, David. Āryabhaa, the Paitāmahasiddhānta, and Greek astronomy. Studies in history of medicine and science, v. 12, no. 1/2, 1993: 69–79.

Plicht, Christof. Joseph von Fraunhofer, 1787–1826. Journal of the Antique Telescope Society, issue 15, summer 1998: 20–21.

Polvani, Anna M. La cometa e gli annali di Mursili II. *In* Studi epigrafici e linguistici sul Vicino Oriente antico. 14; 1997. Verona, Essedue edizioni. p. 17–21.

Pourciau, Bruce H. The preliminary mathematical lemmas of Newton's Principia. Archive for history of exact sciences, v. 52, no. 3, 1998: 279–295. illus.

Pröstler, Viktor. Zeitsignale für die Seefahrt: die astronomischen Hauptuhren der Deutschen Seewarte Hamburg und das Nauener Zeitsignal. Klassik Uhren, 21. Jahrg., Apr./Mai 1998: 22–28. illus. (part col.)

Proverbio, Edoardo. La controversia tra Giovan Battista Amici e Giovanni Grisostomo Gualtieri in merito alla realizzazione di riflettori astronomici (1810–1813). Physis, nuova ser., v. 34, fasc. 3, 1997: 427–488.

Rall, Gloria D. The Native American Bear in the sky. Planetarian, v. 27, Sept. 1998: 13–16, 38. illus.

Rapaport, Michel. Trace et astronomie. *In* Cahiers art et science. 2; 1995. Bordeaux, Éditions Confluences. p. 48–59. illus., port.

Read, John. Ancient timekeeping in Japan. *In* Japan Society, *London.* Proceedings, no. 130, winter 1997: 65–71. illus.

Rius, Mònica. Eclipses y cometas en el *Rawḍ al-qirṭās.* Al-Qanara, v. 19, fasc. 1, 1998: 3–17.

Among the phenomena recorded in this source is the supernova of 1006 (classified as a comet).

Abstract in English.

Rodinson, Maxime. L'espace et le temps chez les anciens Arabes. 1. ptie. Le temps. *In* Matériaux arabes et sudarabiques. nouv. sér., 8; 1997. Paris, Groupe d'études de linguistique et de littérature arabes et sudarabiques, 1998. p. 13–77.

Rodonò, Marcello. In ricordo di Patrick Brendan Byrne (1947–1997). Giornale di astronomia, v. 24, mar. 1998: 55–56. port.

Rodríguez-Sala, María Luisa. Cristobal Gudiel, armero-polvorista real y técnico instrumentista, su actividad técnica y su participación en la observación y descripción del eclipse lunar de noviembre de 1584. *In* Tres etapas del desarrollo de la cultura científico-tecnológica en México. México, D.F., Instituto de Investigaciones Sociales, Seminario Permanente Interdisciplinario de Ciencia y Tecnología, Dirección General de Asuntos del Personal Académico, UNAM, 1996. p. 11–28.

Rudnicki, Konrad. Jak zasada brzytwy Ockhama opóźniła o sto lat rozwój astronomii pozagalaktycznej. Analecta, r. 6, nr. 1, 1997: 321–331.

English summary.

Sabra, Abdelhamid I. One Ibn al-Haytham or two? An exercise in reading the bio-bibliographical sources. [pt. 1] *In* Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften. Bd. 12. Frankfurt am Main, Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 1998. p. 1–50. facsims.

Sagan, Carl. In memoriam: W. Reid Thompson (1952–1996). Icarus, v. 123, Sept. 1996: 2–3. port.

Samsó, Julio, *and* Eduardo Millás. The computation of planetary longitudes in the *zīj* of Ibn al-Bannā'. Arabic sciences and philosophy, v. 8, Sept. 1998: 259–286. illus.

Sarma, Sreeramula Rajeswara. From al-kura to bhagola: on the dissemination of the celestial globe in India. Studies in history of medicine and science, v. 13, no. 1, 1994: 69–85. illus.

Sarma, Sreeramula Rajeswara. The Lahore family of astrolabists and their ouvrage. Studies in history of medicine and science, v. 13, no. 2, 1994: 205–224. illus.

Includes an "interim catalogue" of astrolabes and globes.

Schaffer, Simon. The Leviathan of Parsonstown: literary technology and scientific representation. *In* Inscribing science; scientific texts and the materiality of communication. Edited by Timothy Lenoir. Stanford, Calif., Stanford University Press, 1998. (Writing science) p. 182–222. facsims.

Schaffer, Simon. On astronomical drawing. *In* Picturing science, producing art. Caroline A. Jones, Peter Galison, editors; with Amy Slaton. New York, Routledge, 1998. p. 441–474. facsims.

"... this chapter uses the labors of nebular astronomy in the mid-nineteenth century British Empire to see how astronomical picturing worked, the shared conventions by which it was governed, and the various milieux in which it mattered."

Schnell, Anneliese, *and* Hermann Haupt. Kleine Planeten, deren Namen einen Österreichbezug aufweisen. Ein Beitrag zum 1000jährigen Österreich-Jubiläum 1996 und zum 150. Jahrestag der Gründung der Akademie der Wissenschaften 1997. *In* Österreichische Akademie der Wissenschaften. *Mathematisch-naturwissenschaftliche Klasse.* Sitzungsberichte. Abt. II. 204. Bd.; Jahrg. 1995. Wien, Verlag der Österreichischen Akademie der Wissenschaften, 1996. p. 185–257.

Of the 6,200 asteroids named by the end of 1995, 197 are included here.

Abstract in English.

Sharma, Virendra Nath. Miśra yantra of the Delhi Observatory. Indian journal of history of science, v. 29, July/Sept. 1994: 477–487. illus.

Shea, James H. Ole Rømer, the speed of light, the apparent period of Io, the Doppler effect, and the dynamics of Earth and Jupiter. American journal of physics, v. 66, July 1998: 561–569. illus.

Sheehan, William, *and* Thomas A. Dobbins. Le Verrier's wild geese. Sky & telescope, v. 96, Oct. 1998: 112–115. illus. (part col.), ports. (Observer's log)

Observations of objects transiting the sun, reported occasionally during the 19th century and interpreted as supporting the idea of an intra-Mercurial planet, may well have been sightings of distant birds, as proposed by C. H. F. Peters in 1869.

Snedegar, Keith V. First fruits celebrations among the Nguni peoples of southern Africa: an ethnoastronomical interpretation. *In* Archaeoastronomy. no. 23; 1998. Cambridge, Science History Publications. p. S31–S38.

Šolcová, Alena. Místo posledního odpočinku Jana Marka Marci? DVT, Dějiny věd a techniky, roč. 31, čís. 1, 1998: 47–48.

Soulié, Edgar J. French astronomers, visual double stars and the double stars working group of the Société Astronomique de France. *In* Pacific Rim Conference on Recent Development on Binary Star Research, *3d, Chiang Mai, 1995.* Proceedings of a conference sponsored by Chiang Mai University, Thai Astronomical Society, and the University of Nebraska-Lincoln held in Chiang Mai, Thailand, 26 October-1 November 1995. Edited by Kam-Ching Leung. San Francisco, Astronomical Society of the Pacific, 1997. (Astronomical Society of the Pacific conference series, v. 130) p. 291–294.

Stadler, Leopold. Eine zweite Armillarsphäre von Christian Carl Schindler. *In* Der Globusfreund. Nr. 45/46; 1997/98. Wien, Internationale Coronelli-Gesellschaft für Globen- und Instrumentenkunde, 1998. p. 197–206. illus. (part col.)

The plates, no. 22–25, are bound at the end of the issue.

Summary in English.

Stautz, Burkhard. Mit dem Himmel in der Hand: Astrolabien und die Astrolabiensammlung des Deutschen Museums. Kultur & Technik, 21. Jahrg., Nr. 2, 1997: 38–41. illus. (part col.)

Another color illustration appears on p. 3.

Steel, Duncan. The ABC of ACM: asteroids, Buffon and comets. Planetary and space science, v. 45, Dec. 1997: 1501–1503. illus.

Steele, John M. Predictions of eclipse times recorded in Chinese history. Journal for the history of astronomy, v. 29, Aug. 1998: 275–285. illus.

Stephenson, F. Richard, *and* Leslie V. Morrison. Long-term fluctuations in the Earth's rotation: 700 BC to AD 1990. *In* Royal Society of London. Philosophical transactions, physical sciences and engineering, v. 351, Apr. 15, 1995: 165–202. illus.

Steves, B. A. The cycles of Selene. Vistas in astronomy, v. 41, pt. 4, 1997: 543–571. illus.

"The discovery and use of the Saros, a lunar cycle of 18 years and 10 or 11 days, is reviewed from its earliest origins two millennia ago to the present day, when it is known with precision and enables the accurate prediction of both time and type of solar and lunar eclipses."

Stoffel, Jean F. La révolution copernicienne et la place de l'Homme dans l'Univers. Étude programmatique. Revue philosophique de Louvain, t. 96, fév. 1998: 7–50.

Abstract in English.

Stroup, Alice. Christian Huygens et l'Académie royale des sciences. La Vie des sciences, t. 13, no 4, 1996: 333–341. illus., port.

Sturdy, David J. Dynasticism in the Académie: the La Hire family. *In his* Science and social status: the members of the Académie des sciences, 1666–1750. Woodbridge, Suffolk, Rochester, NY, Boydell Press, 1995. p. 193–213. geneal. table.

The book also contains brief sections on Auzout (p. 80–82), the design and construction of the observatory (p. 151–153), J. D. Cassini and Ole Rømer (p. 182–184), and d'Alembert (p. 395–397). Basic data on the academicians appointed 1669–98 and 1702–50 are provided in appendices.

Tachau, Katherine H. Et maxime visus, cuius species venit ad stellas et ad quem species stellarum veniunt. *Perspectiva* and *astrologia* in late medieval thought. *In* Micrologus. v. 5; 1997. La visione e lo sguardo nel Medio Evo: View and vision in the Middle Ages. 1. Firenze, SISMEL. p. 201–224. illus., facsims.

The 14 illustrations appear on 12 p. of plates following p. 224.

Thorel, Jean C. Les catalogues stellaires, bibles des astronomes. Ciel et terre, v. 114, mai/juin 1998: 113–121. ports.

Thro, E. Broydrick. Leonardo's early work on the pinhole camera: the astronomical heritage of Levi ben Gerson. *In* Achademia Leonardi Vinci. Journal of Leonardo studies & bibliography of Vinciana. v. 9; 1996. Edited by Carlo Pedretti. Firenze, Giunti. p. 20–54. illus., facsims. (part col.)

"Appendix I: Leonardo's Early Studies of Shadows, including CA, f. 187 r-a, v-a. Parallels with the Pinhole Camera and Anticipation of Francesco Maurolico's *Photismi*": p. 42–50.

"Appendix II: Leonardo's Astronomy: Sources and Authorship of the Codes Huygens": p. 51–54.

Most of the illustrations are reproduced on unnumbered plates bound at the end of the volume.

Tieder, Irène. Le calendrier républicain et ses incidences littéraires. Annales historiques de la Révolution française, no 292, avril/juin 1993: 259–267.

Abstract in English: p. 344.

Trimble, Virginia. Can't you keep Einstein's equations out of my observatory? pt. 1. Beam line, v. 28, summer 1998: 35–40. illus.

"... the focus is on interchanges of ideas between astronomy and other parts of science."

Trimble, Virginia. Cosmic abundances: past, present, and future. *In* October Astrophysics Conference, *6th, College Park, Md., 1995.* Cosmic abundances. Proceedings of the Sixth Annual October Astrophysics Conference in College Park, Maryland, 9–11 October 1995. Edited by Stephen S. Holt and George Sonneborn. San Francisco, Astronomical Society of the Pacific, 1996. (Astronomical Society of the Pacific conference series, v. 99) p. 3–35. illus.

Trimble, Virginia. What, and why, is the International Astronomical Union? Beam line, v. 17, winter 1997: 43–52. ports.

Trinkner, Diana. Träume von Levania. Zur Rezeption neuer naturwissenschaftlicher Erkenntnisse am Beispiel von Galileis *Sidereus Nuncius* und Francis Godwins *The Man in the Moone. In* Morgen-Glantz; Zeitschrift der Christian Knorr von Rosenroth-Gesellschaft. 8; 1998. Bern, New York, P. Lang. p. 227–254. facsims.

Tubridy, Michael. The re-construction of the 6-foot Rosse Telescope of Ireland. Journal of the Antique Telescope Society, issue 14, winter 1998: 18–24. illus., facsims., ports.

Turner, Anthony J. Le cadran solaire de Benjamin Scott. La Revue, Musée des arts et métiers, no 24, sept. 1998: 55–57. col. illus.

Van Brummelen, Glen. Computer animations of Ptolemy's models of the motions of the sun, moon and planets. Journal for the history of astronomy, v. 29, Aug. 1998: 271–274. illus.

Vasoli, Cesare. La difesa dell'astrologia di Luca Gaurico. *In his* Civitas mundi: studi sulla cultura del Cinquecento. Roma, Edizioni di storia letteratura, 1996. (Storia e letteratura: raccolta di studi e testi, 194) p. 313–327.

Veer, Frans van 't. Christiaan Huygens: des lunettes plus en plus longues. L'Astronomie, v. 112, avril/mai 1998: 110–113. ports.

Another portrait is reproduced on the outside front cover of the issue.

Vermij, Rienk H. Waarom werd Philips Lansbergen Copernicaan? Scientiarum historia, 24. jaarg., nr. 1, 1998: 39–64. facsims.

Waters, D. W. Obituary. Lieutenant Commander Derek Howse, MBE, DSc, Royal Navy, FSA, FRIN, FRAS. Bulletin of the Scientific Instrument Society, no. 58, Sept. 1998: 2–3. port.

Watson, Fred. The universal astronomer: David Allen, 1946–1994. *In* Yearbook of astronomy. 1996. Edited by Patrick Moore. London, Macmillan, 1995. p. 126–140. illus., port.

Wild, Paul, *and* Werner Gurtner. Prof. Max Schürer (1910–1997). Orion, 56. Jahrg., Aug. 1998, Mitteilungen: 1–2. port.

Willach, Rolf. The early history of the achromatic objective. Journal of the Antique Telescope Society, v. 12, winter 1997: 4–13. illus., port.

Williams, Thomas R. John Edward Mellish and the origins of the amateur telescope making movement in North America. Journal of the Antique Telescope Society, issue 13, summer 1997: 15–19.

Witt, Volker. SuW-Besuch beim Royal Greenwich Observatory. Sterne und Weltraum, 37. Jahrg., Nr. 6, 1998: 576–579. col. illus., col. port.

Wood, Christopher. The determination of the difference in meridians of the Paris and Greenwich observatories. Antiquarian horology, v. 24, autumn 1998: 234–236. illus., port.

Yavetz, Ido. On the homocentric spheres of Eudoxus. Archive for history of exact sciences, v. 52, no. 3, 1998: 221–278. illus.

Young, Edward J. Foerster and Archenhold: a legacy of popular astronomy in Berlin. Journal of the Antique Telescope Society, issue 14, winter 1998: 16–17. illus.

Zenkert, Arnold. Die beste volkstümliche Himmelskunde. Zum 50. Todestag Bruno H. Bürgels am 8. Juli 1998. Sterne und Weltraum, 37. Jahrg., Nr. 7, 1998: 670–671. col. port.

Zhou, Hongnan, Weifeng Zhuang, *and* Yu Wang. New reductions of orbits based upon Chinese ancient cometary records. Planetary and space science, v. 45, Dec. 1997: 1551–1555. illus.

Zimbrón, Rafael. El solsticio de invierno en el Valle de México. México desconocido, año 22, dic. 1997: 18–26. col. illus., col. facsim., col. map.

"Las civilizaciones contemporáneas a Cuicuilco y Teotihuacan crearon un calendario muy exacto, empleando para ello los movimientos aparentes del Sol, la Luna y las estrellas sobre los horizontes este y oeste, cuya configuración está definida por los grandes volcanes que limitan la cuenca.

¿Como se llevaba a cabo esta actividad astronómica y calendárica?"

Includes two boxes, "Solsticios" (p. 23) and "Fenómeno solar" (p. 24).

Zoller, Robert. The hermetica as ancient science. Culture and cosmos, v. 1, autumn/winter 1997: 23–34.

R S Freitag
Library of Congress
October 1998

Reviews

The Einstein Tower: An Intertexture of Dynamk Construction, Relativity Theory, and Astronomy, by Klaus Hentschel; translated by Ann M. Hentschel (Stanford University Press, Stanford, 1997) 226 + xii pp., ISBN 0-8047-2824-0, US$45, hardback, 240 × 155 mm.

Before beginning my review, I should declare an interest. One of the central characters in the book, Erwin Finlay-Freundlich, was my principal teacher in my undergraduate years and Hentschel has made considerable use of my own published reminiscences of the man. I am not a completely disinterested reviewer.

The book is not, and does not claim to be, a complete biography of Freundlich. Although the book does include some description of both Freundlich's earlier and later years, it centres on his building of the solar observatory in Potsdam that became known as "the Einstein tower". This was scientifically the most important and productive period of his life, the period when he worked with Einstein, and was something of an *enfant terrible* among the much more conservative German astronomers who had little time either for relativity theory or for the newly-developing field of astrophysics. By concentrating on this period of Freundlich's life, Hentschel has room to deal also with two other important figures: Einstein, the founder of general relativity and Eric Mendelsohn, the architect of the tower. These three men came together before 1920 and conceived the idea of an observatory dedicated to the astronomical testing of the theory of general relativity. Einstein provided the theory and a celebrity name; Freundlich raised the funds and devised the scientific programme, eventually becoming the Director; Mendelsohn created the tower. Despite the success of the enterprise, the men gradually drifted apart, there being many sources of friction, particularly between Einstein and Freundlich. Even if they had all remained friends, however, a darker destiny would have forced them apart. The tower was completed in 1921, but its instruments were not ready until barely a decade before the rise to power of Hitler and his Nazi party. Einstein, Freundlich, and Mendelsohn all had at least some Jewish ancestry and, therefore, had to leave Germany. This was one reason why the tower was not as scientifically productive as had been hoped. Freundlich went first to Turkey, then Czechoslovakia, which, naturally, he had to leave after the Munich crisis. Events brought him to Scotland (his mother's native country) and there he became first lecturer, later Professor, of astronomy in the University of St. Andrews. He took the legal name Finlay-Freundlich, although colleagues and students usually continued to address him by his original name. It was there that I encountered him; by coincidence I found myself reading this book just about the time that I reached the age Freundlich was when I first met him.

Despite the fact that in St. Andrews he inspired the building of an experimental Schmidt-Cassegrain telescope, Freundlich himself came across to me as a rather conservative mathematical astronomer of the old school. He taught astrophysics, but my feeling was that he was much more at home with traditional celestial mechanics (which he taught very well) and stellar statistics. Hentschel makes clear, however, that Freundlich, in his German years, not only was an enthusiastic advocate of relativity theory, but also kept up with the latest developments in astrophysics, in the face of a sceptical, even hostile, German astronomical establishment. Hentschel quotes Wali's biography of Chandrasekhar, who was charmed by Freundlich, during a visit to Potsdam in 1931, and delighted at the understanding the latter showed of his work (the work on relativistic degeneracy that had been so fiercely criticized by Eddington). Kopal also describes in his autobiography how Freundlich seemed like a breath of fresh air to young Czech students who had previously had only an old-fashioned astronomical education. Kopal, indeed, once told me that Freundlich, in his St.

Andrews years, was but a pale shadow of his former self. Unfortunately, a certain impetuosity in Freundlich's nature, still evident when I knew him, led him in those early days to publish some rather questionable papers that did nothing to improve his standing with the old school.

A paradox of Freundlich's life was that, although he began as a staunch advocate of relativity, he became increasingly sceptical of it as he grew older. To two of the classical astronomical tests of the theory, the gravitational red-shift (particularly in the light from the Sun) and the deflection of starlight passing near the Sun during a total eclipse, he made important contributions of his own and he knew at first hand, therefore, the difficulties of obtaining observational confirmation for these tests. As far as I know, he made no investigations of his own on the movement of the perihelion of Mercury, but he would impress on his students that this motion was not observed directly, and that the quoted value was in fact the difference between two very large directly observed quantities, and therefore uncertain. It was not as idiosyncratic in the 1950s as it would be now to be sceptical of general relativity, but Freundlich's scepticism led him to develop a theory of photon-photon interaction (a version of tired-light theory) that would explain the red shifts of distant galaxies without the need of postulating an expanding universe. Hentschel discusses this theory, but it has never, of course, been accepted by the mainstream of cosmologists.

The portrait of Freundlich that emerges from this book is not entirely flattering, but I think Hentschel tries hard to be fair and does make clear that Freundlich was an important figure in German astronomy between the world wars, and well-known outside the country. He also had the courage, as long as he remained in Germany, to stand up to the Nazis and to those among his colleagues who tried to curry favour with them. In my undergraduate years, I revered the man, perhaps excessively, but he has been largely forgotten, by most astronomers, since his death in 1964. I am glad to see a book that does something to restore him to his rightful place in the history of twentieth-century astronomy. This book is a translation (by Ann Hentschel) of a book that first appeared in German a few years ago. The translation reads smoothly, and one is rarely, if ever, aware of reading something that was not originally written in English.

Alan H Batten.

Astronomie der Goethezeit, Textsammlung aus Zeitschriften und Briefen, Franz Xaver von Zachs, Ausgewählt und kommentiert von Peter Brosche (Verlag Harri Deutsch, Thun and Frankfurt am Main, 1998), Ostwaids Klassiker der Exakten Wissenschaften , Band 280, 230 pp., ISBN 3-8171-3400-2, soft cover, 120 × 190 mm.

The Goethe era 1749-1832 is characterized by the French Revolution, the rise of Napoleon, and consequent unrest in Europe. Despite these marked, adverse external circumstances, as the author notes in his introduction, there commenced a silver period of German Astronomy. The Goethe era identifies specifically the achievements of this period, the district of Thüringen and particularly the town of Gotha and Franz Xaver von Zach.

Human curiosity towards the mysticism of natural events and the splendour of the night sky inspired man and woman towards recognition, collection, and interpretation of the obtained information of the external world. The gained experiences stimulated them to pursuit of activity and to succeed in acquiring broad knowledge about Earth and the celestial sphere.

Modern astronomy embraces all aspects of space, matter, and time. In Goethe's time, with no electric light, no motor engines, no railways and travel by horse and carriage, our constrained knowledge of the universe reflected only the basic, observed phenomenon. Nevertheless, at this time the observational study of the position and motion of the celestial bodies and the mathematical study of their orbital motions was prospering, in addition to the effort to obtain by geodetic survey the shape and size of the planet Earth.

Franz Xaver von Zach 13.6.1754 - 2.9.1832 as an Engineer with a study of mathematical sciences participated in the geodetic survey of Austria. He travelled extensively through Europe and England and became acquainted with many of the contemporary scientists and astronomers. He came to prominence with the establishment of the astronomical observatory of Seeberg, Gotha, and was its first Director. Zach's life ended in the Autumn of 1832 on the second of September at the age of 78 years and he was buried in the church courtyard at Père de la Chaise in Paris.

Except during his final illness, Zach was untiring in his efforts to promote astronomy by observations, calculations, and publications thereby providing a new impetus for the astronomy of Germany.

Zach secured financial and essential support from Duke Ernst II von Sachsen-Gotha, who from generosity towards advances of science and astronomical observation supported the foundation in Gotha of an observatory and its operation with his own financial means. During his Directorship, the observatory in Seeberg became, over a few years, a converging point of astronomical research and a meeting place for astronomers. He initiated the groundwork for conferences and congresses, publication of the first astronomical periodical and many reports. Devoted, he supported the promotion of a society for co-ordinated research and collaboration between the various disciplines in astronomy and geodesy. With his standing, Zach was able to provide patronage and promotion to talented scientists and astronomers.

Besides previous publications in BAJ *Astronomisches Jahrbuch Berlin*, the first periodical publication, *Allgemeine Geographische Ephemeriden,* containing astronomical and Geographic-Geodetic information, was published by the director of the Duke Observatory in Gotha, F. von Zach. These published transitory positions, calculated in advance, were relevant for observers to swiftly compare their observed results.

Zach did not hide his interest in all aspects of geodesy and is considered the founder of Gotha cartography, publishing numerous single maps of sea and land and, of course, star charts.

The first astronomical conference in Gotha was also the first international congress for the establishment of a metric measuring system, as proposed by France but which now failed due to strong opposition, particularly from Germany. Nevertheless Lalande's friendship with Zach was an important link between the French and German astronomers at that time.

Several significant conclusions were reached at this point in time:

◊ The periodic nature of comets was recognized.
◊ The number of known planets was increased by one to six following the discovery of Uranus by Herschel in 1781.
◊ The extraterrestrial nature of meteorites was commonly accepted.
◊ The discovery of the first asteroid, Ceres, by Piazzi in 1801 although not entirely unexpected as this closed the long known gap in the Titius-Bode-Law of a 'missing' planet between Mars and Jupiter. Soon a further three asteroids were detected, two by Olbers and one by Harding.
◊ Black Holes were proposed by Laplace as consequence of the deflection of light by gravity, despite the fact that Laplace was not the first to postulate this.
◊ The cosmological consideration by Anton Baron von Zach (brother of Franz Xaver von Zach) that Earth once had countless moons, the closest smaller and the remotest larger, which after collisions accreted to form an enlarged Earth - with the largest, our Moon, remaining.
◊ The development and application of the mathematical *Least Squares Solution* by Gauss.

◊ The publication of the first astronomical periodical and, lastly, the foundation of the first Astronomical Society.

From his early years, Zach was concerned with land survey, contributing much towards the astronomical determination of geographical coordinates and azimuth, measurement of base lines, and triangulation. He was very excited when in 1803 the King of Prussia commissioned him to pursue such an endeavour. He set out the project needed to obtain maps of high precision, incorporating the curvature of Earth's ellipsoid to conform with its projection onto a plane. Due to the outbreak of war, only the outlines of this project were realised, and its completion had to await later activity by Captain Müffling of the Prussian Survey Corps.

Zach performed astronomical determinations of geographical position in the south of France by means of gunpowder flash signals reflected on the clouds. This innovation permits time transfer over long distances and the derivation of an accurate chronometer correction – thus improving the astronomically-obtained geographic positions used to confirm the accuracy of the triangulation network. Since in astronomy improvements were achieved in the determination of refraction, precession, parallax, declination of the Sun and stars, and aberration and nutation, Zach deemed it necessary to now repeat observations to improve their accuracy. With this enhancement, a comparison with the measured baselines and triangulation network positions (considered to be measured accurately and less influenced over time) yields a more satisfactorily correlation.

As indicated in the title, the author selects text from journals and letters from Baron Franz Xaver von Zach then annotates his own comments to contemporary scientific events and progress at this time in history. Peter Brosche also intends concurrently to promote the life and achievements of Baron Xaver von Zach, though not well known, was certainly a significant researcher, observer, communicator and organiser, who certainly deserves an ample and lasting recognition for his achievements.

The style of this early period in German literature, filled as it is with somewhat excessive courtesy, provides easy and stimulating reading and is recommended to everyone interested in the history of science, astronomy, and geodesy.

Ivan Nikoloff

The Eddington Enigma, by David S. Evans, (privately published 1998, copies available from: Xlibris Corporation, PO Box 2199, Princeton, NJ, 08543~2199, USA) 200 pp., ISBN 07388-0131-3, hardcover, US \$25 + \$4.95 shipping and handling, ISBN 0-73880132-1, softcover, US \$15 + \$4.95, 210 × 135 mm.

This is another book in which I must declare an interest; not only have I written on the subject of Eddington myself, but the author is a long-time friend. He had hoped to produce this book in time for the fiftieth anniversary of Eddington's death in 1994, but this did not prove to be possible. Evans is one of the declining band of those who actually knew Eddington, although, as he makes clear, his contacts with the great man were few.

The chief enigma about Eddington, of course, is why one who had contributed so much to astronomy in his earlier years should have devoted himself almost exclusively, in later years, to the pursuit of the theory that all the major laws and constants of nature could be derived by pure thought. Eddington never convinced more than a few of his contemporaries, and most people ignore his ideas now, although they are not so very different from the modern search for a 'theory of everything'. Evans argues that one cannot understand Eddington's position unless one first understands his religious faith as a Quaker, and the importance it had for him. I agree with this completely, and have, in fact argued the same myself.

Along the way, Evans gives us a good account of all Eddington's scientific work. He does not attempt a detailed biography, but he does enliven the book by his personal reminiscences of the man, and of the kind of society in which both he and his subject lived. The brief description of the kind of house in which the young Eddington grew up, for example, is masterly, and will bring back memories to anyone who has lived in a similar house (as this writer did in his graduate-student days in Manchester). The famous controversy with Chandrasekhar inevitably figures here, of course, and Wali's biography of the latter is quoted in this book, as well. This controversy forms a lesser enigma about Eddington: time has shown that, scientifically, he was in the wrong (unusual for him), but he also acted out of character in the way he criticized Chandrasekhar. My own feeling is that rather too much has been made of this incident. Wali has represented it as having deeply hurt Chandrasekhar, but the latter himself makes clear, in his own account, that he remained in friendly correspondence with Eddington long afterwards. Evans quotes an obituary of Chandrasekhar by McCrea, who also believes that the significance of the controversy has been exaggerated. The lesser enigma is thus compounded, since Wali was in a position to check with Chandrasekhar about his feelings, while McCrea knew both men at the relevant time.

The book contains a number of unusual illustrations, including replicas of the title pages of books from Eddington's library, now owned by David Evans. Unfortunately there is no index, but Evans does reproduce Douglas's bibliography of Eddington's work, which, in view of the fact that her book (see below) is now out of print, will be useful for many people. The book was prepared from the author's own typescript. All of us know that, even with modern word-processors and spell-checkers, it is almost impossible to type something of this length without errors. It is to the author's credit that such typographical errors are few in number, and in nearly all instances the intended meaning is clear. It is, however, a little unfortunate that Chandrasekhar's life was cut short by forty years on p. 145.

The book has been published privately, because no academic press was prepared to accept it for publication. This is a pity and, in my opinion, reflects as much on the process of peer review, as it is sometimes practised, as on the quality of the text. Of course, there is already an authorized biography of Eddington, by A. Vibert Douglas, to which Evans refers frequently, and this may have contributed to a perception that the market for another would be limited. (Scientific biographies, as I have learned, do not become best-sellers!). Nevertheless, Eddington was a giant in astronomy, and there is surely room for more than one appreciation of his significance. While authorized biographers have the advantage of access to private documents and family memories, they also find it harder to be objective. I think Evans often gives a clearer exposition of the science than Douglas (who graciously autographed my copy of her book) does, and he discusses matters that she does not, such as why did Eddington not found a school of disciples to continue his work. On the other hand, Douglas undoubtedly knew Eddington and his sister better than Evans did, and probably does a better job of bringing out his personality and his beliefs. Neither book is definitive, but both can be read with pleasure and profit by those who are fascinated by Eddington. My own paper on the man brought me several letters from those who, as I did myself, devoured Eddington's popular books in their childhood and were thus influenced to choose astronomy as a career. He never married and so had no children or grandchildren of his own, but he had an influence on the two generations to which such descendants would have belonged that probably exceeded anything he ever imagined.

Alan H Batten.

GUIDE FOR AUTHORS

GENERAL

1. There are no page charges. All contributions must be in English language.
2. Manuscripts should be typewritten on one side only and single-spaced on A4-size paper with side margins of not less than 25 mm wide. Text should be justified.
3. First lines of each paragraph should be indented except for those immediately under a heading.
4. A line space should be left before headings and a half-line space before and after indented quotations. There is no space between a heading and the following text.
5. All pages – including references, tables and captions – should be numbered.
6. The Abstract should not be longer than 300 words. It should be intelligible in itself without reference to the rest of the paper.
7. Up to five key words for indexing should be listed under the Abstract.
8. The use of S.I. units is recommended.
9. Dates should be listed in the form "1857 September 16" or "1857 September".
10. The first page of the paper should include the title of the paper, and the name, postal address, and e-mail address of the author(s).
11. Where possible, papers should be e-mailed to John Perdrix, at:
    astral@dragon.net.au
    Tables should be included, but it is not necessary, at this stage, to e-mail figures – only the list of figures. For those without e-mail facilities, three hard copies of the paper, including references, tables, figure captions, and photocopies of all figures, should be sent to:
    John Perdrix, Astral Press, PO Box 107, Jolimont DC, WA 6913, Australia

HEADINGS

1. The following hierarchical system of headings is employed:

   3 DISCUSSION
   3.1 Important Developments in Astronomical Spectroscopy
   3.1.1 Kirchoff's Contribution

   Note that the 3 and 3.1 headings are in **bold** print (and that 3.1.1 is not).
2. Apart from the Abstract, all headings (including "Acknowledgements" and "References") should be numbered, and should be left-justified.

TABLES

1. Tables should be planned to fit the printed B5 format (135 mm wide and 200 mm high).
2. Each table should be typed on a separate sheet or sheets, and all tables should be collected together at the end of the text.
3. Tables should be numbered consecutively according to their position in the text.
4. Each table must be cited in the text.
5. Every table should have a short title.
6. Vertical lines are not required to separate columns; extra space is sufficient.
7. Zero must be placed before the decimal point in all values less than 1.0.
8. If references are used in tables, be sure to include them in the list of references.
9. Column headings should be brief with the units indicated in the line below between parentheses.

FIGURES

1. "Figures" include line drawings and half-tones (black and white photographs).
2. Line drawings must be clear and sharp. If they are draughted (rather than computer-generated) use Indian ink on white drawing paper or film.
3. On line drawings, lettering, line thickness, and other details should be large enough to be legible after reduction to a B5 page size.
4. Half-tone photographs should be on gloss paper with good contrast. Colour photo-graphs cannot be included (but black and white reproductions of them are acceptable).
5. Use bar scales to indicate size so that reduction is possible.
6. All figures should be planned to fit the printed B5 format (135 mm wide and 200 mm high) or part thereof.
7. Figures should be numbered consecutively according to their position in the text.
8. Each figure must have a caption. A list of "Figure Captions" should be supplied on a separate sheet(s) at the end of the manuscript.

INDICATIONS

1. Equations and symbols must be clear.
2. Equations should be numbered sequentially at the right hand margin.
3. Greek letters and unusual symbols should be identified by a pencil note in the margin.
4. Indicate clearly the difference between similar letters and numbers, for example., the letter "l" and the number "1"; the letter "o" and zero (0); the letter "u" and mu (μ); the letter "n" and eta (η).
5. Give the meaning of all symbols immediately after the equation in which they are first used.
6. Indicate clearly subscripts and superscripts.
7. Avoid root signs if possible and use fractional powers.
8. For simple fractions use the solidus (/) instead of a horizontal line.
9. Use standard symbols and notations whenever possible.

QUOTATIONS

1. Quotations of about 30 words or less should be set in the text within double quotation marks.
2. Longer quotations should be indented (left and right), without the use of quotation marks.
3. All underlining, italics, superscripts and subscripts that appear in the original sources should be faithfully reproduced in the quotations.
4. Any insert by the author within a quotation should be placed in square brackets.

REFERENCES

1. These should be cited in the text by author's name and date of publication in parentheses, appropriate pages may be included. Examples are: "Since Osterbrock (1990) has shown ..."; "... found by Dick (1992:15-17)"; "... later results have confirmed this (Warner, 1993)."
2. Publications written by more than two authors are referred to in the text by the first author plus "*et al.*"; however, in the reference list all authors should be included.
3. References in the text should be arranged alphabetically by author, for example., "... is well covered (see Batten, 1997; Dick, pers. comm., 1994; Gascoigne, 1992; Kochhar, 1990)."
4. All references to publications made in the text, tables, and figure captions should be put into a list, separate from the text.
5. The list of references should be arranged alphabetically by authors' names and chronologically if there is more than one reference for an author.
6. All references in the list must be cited in the text.
7. The following should be used as guides for references:

For periodicals

Andrews, A.D., 1997. Cyclopaedia of telescope-makers. Part 7: T-Z. *The Irish Astronomical Journal*, **24**:125-192.

Chapman, A., 1983. The accuracy of angular measuring instruments used in astronomy between 1500 and 1850. *Journal for the History of Astronomy*, **14**:133-137.

Obituary: Sir Joseph Norman Lockyer. *Monthly Notices of the Royal Astronomical Society*, **81**:261-266 (1921).

For newspaper entries

Tebbutt, J., 1861. The comet. *The Empire*, June 26.

The Comet. *The Empire*, June 28 (1861).

For edited symposia, proceedings, etc.

Jeffery, P.M., Burman, R.R. and Budge, J.R., 1989. Wallal: the total solar eclipse of 1922 September 21. In D.G. Blair and M.J. Buckingham (eds.), *Proceedings of the Fifth Marcel Grossman Meeting*. University of Western Australia, Perth, pp. 1343-1350.

For monographs, books, and chapters of books

Colonial Astronomer: Copies of all Correspondence Between the Governor General and the Secretary of State Respecting the Appointment of the Rev. W. Scott as Colonial Astronomer. Government Printer, Sydney (1857).

Howse, D., 1989. *Nevil Maskelyne. The Seamen's Astronomer*. Cambridge University Press, Cambridge.

Sullivan, W.T., 1988. Karl Janksy and the beginnings of radio astronomy. In K. Kellerman and B. Sheets (eds.), *Serendipitous Discoveries in Radio Astronomy*. National Radio Astronomy Observatory, Green Bank, pp. 39-56.

For unpublished sources

Airy, G., 1857. Letter to P.P. King, dated October 30. Mitchell Library, Sydney (AR 4216).

Berendzen, R., 1968. The career development and education of astronomers in the United States. Unpublished Ph.D. Thesis, Harvard University.

Tebbutt, J., 1860-61. Astronomical Observations. MS, Mitchell Library, Sydney (AR 3647).

Tebbutt, J., 1874. Untitled journal of transit of Venus observations. MS, Mitchell Library, Sydney (AR 3682).

For second-hand references

Lassell, W., 1847. Discovery of a new planet. *Monthly Notices of the Royal Astronomical Society*, **8**:83. Cited by J.L. Perdrix in *Journal of the Astronomical Society of Victoria*, **33**:86-92 (1980).

8. Note that the names of periodicals should be given in full.

FOOTNOTES AND ENDNOTES

1. Footnotes should be avoided if possible, but, if essential, they should be indicated by the following symbols: asterisk (*), dagger (†), double dagger (‡), section mark (§), and paragraph mark (¶).
2. If used, they should be kept as short as possible, and supplied on a separate sheet(s) at the end of the text. As most work is presented to the printer as camera-ready, it is best to avoid these and use endnotes.
3. Endnotes should be indicated in the text by superior figures (small figures placed above the line of text). The endnotes are gathered under a numbered heading immediately before the list of references.
4. If references are given in footnotes and/or endnotes, be sure to include full details in the list of references.

CHECK LIST AND ORDER

Title page, Abstract and key words, Text, References, Tables, Figure captions, Photocopies of figures

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Cover illustrations show a series of images of the η Carinae area beginning with a drawing by John Herschel published in 1847, a black and white photograph taken by Ben Gascoigne with the MSSSO 40-inch reflector at Siding Spring, a colour photograph taken by David Malin with the AAO 150-inch at Siding Spring, and a view taken with the Hubble Space Telescope, courtesy J Morse (U. CO), K Davidson (U. MN), and NASA.