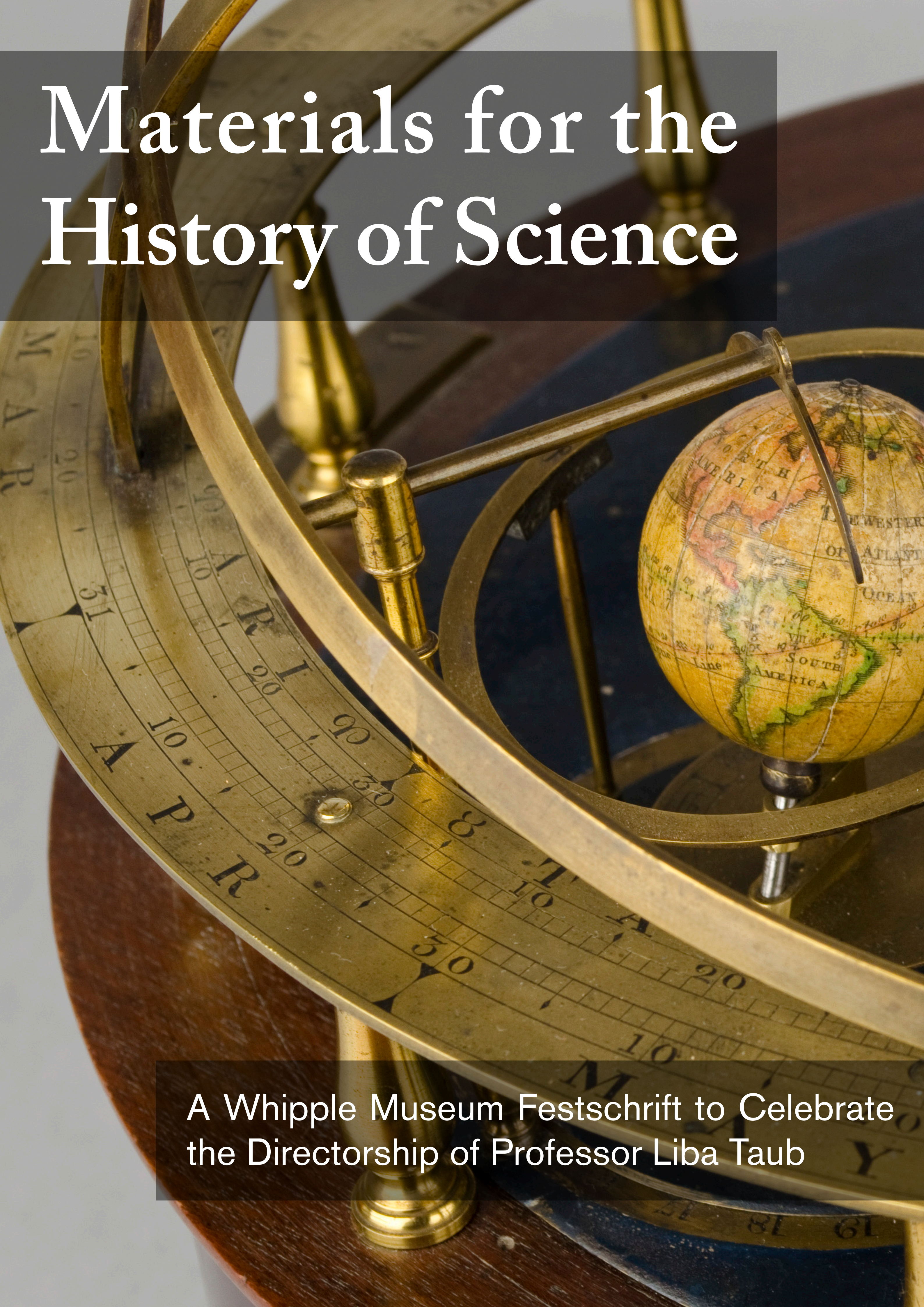
Materials for the History of Science



A Whipple Museum Festschrift to Celebrate the Directorship of Professor Liba Taub

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to Celebrate the Directorship of
Professor Liba Taub

Edited by Joshua Nall, James Hyslop,
and Boris Jardine

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Introduction

Liba retires this year after serving for more than twenty-seven years as Curator and Director of the Whipple Museum of the History of Science. Her tenure has been defined by many things, with growth a consistent theme. Growth of the Museum itself, in footprint and in staff, and growth too of the collections, which have increased in size by more than 50% since her arrival in Cambridge in the winter of 1995. But perhaps the most significant growth to occur under her stewardship has been reputational. The Whipple Museum is now widely recognised as a global leader in the study of the history of scientific material culture.

This book celebrates Liba's career in museums by bringing together the two elements that have helped build the Whipple's world-class reputation: the collection of diverse and curious objects, apt for the scholarly study of past scientific practice; and the mentorship of several generations of scholars and museum professionals who have worked alongside and learned from Liba. We have invited many of these friends, colleagues, and acolytes to select a favourite object from amongst the extraordinary materials acquired during her tenure, and asked them to reflect upon it. In many cases this has resulted in deep scholarly analysis of a single instrument; in others, it has led contributors to recollect their time working with Liba, and on the profound influence that this work has had on their lives and careers.

So this is a book about objects, but it is also a book about people. More than any single acquisition, Liba's legacy is defined by her influence on the wider museum community. Many of the authors in this volume (not to mention all three editors) started their careers at the Whipple, whilst many others have undertaken periods of productive research using the collections that Liba has stewarded and grown. Indeed, the sheer number of authors gathered here is testament to Liba's extraordinary impact. Wherever they are now – and many remain in science museums and the academy – the unifying factor among our contributors is their intellectual and professional debt to Liba and the Whipple Museum.

The impact of this legacy will be felt long after Liba retires. Her mentorship of numerous historians and museum professionals is already influencing the way that objects are researched and exhibited in museums around the world. Some of those who have learnt from Liba are only now beginning their careers in museums; they too will mentor and train future generations, passing on to them what they have acquired during their time at the Whipple. And as this volume attests, Liba's astute curatorial eye has ensured the preservation of a diverse and invaluable set of materials for the study and display of past science.

Along with the Whipple collections, in 1995 Liba took on the management of an acquisitions budget that formed part of the original R. S. Whipple bequest to the University of Cambridge. During her twenty-seven years at the Museum the scientific instrument market has undergone huge changes, and it is testament to Liba's curatorial judgement that the Whipple has been able to both purchase and acquire by donation many superb objects that together rival any of the major instrument collections in the world. At the same time, Liba has also kept a careful eye out for more unusual and perhaps overlooked instruments that with the hindsight of a few decades seem to have been picked up for a bargain. Never afraid to walk away from an object that seemed overpriced, Liba's responsible stewardship has ensured that her successors will have both a rich array of materials to work with and a healthy war chest to carry on the tradition of growing the Whipple's collections.

The entries that follow are presented in the order in which the objects were accessioned, starting with two items that both plausibly lay claim to the title of Liba's first acquisition. Fittingly, these pieces illustrate the diversity that has come to be a hallmark of Liba's curation: an aquatint of Cambridge Botanic Garden; and a set of medals celebrating Georgian science and industry. In some cases, the same object has been chosen independently by two different authors; such duplication was far from discouraged, as Liba has always championed the development of multiple research perspectives on a single object. And a few entries are unsigned; in these cases the editors have selected acquisitions that we judged to be of particular interest, and have compiled short accounts of them based on existing scholarship on file at the Whipple Museum.

We thank all the contributors to this volume for taking the time to write such a rich and diverse set of accounts, which together record an exemplary survey of the remarkable range of objects and influences that define Liba's career in museums.

Joshua Nall, James Hyslop, and Boris Jardine
Cambridge, June 2022

The editors would like to thank Morgan Bell, Toby Bryant, Jenny Bangham, and Steve Kruse for their assistance in the production of this volume. We are also grateful for the support of the Department of History and Philosophy of Science.

Aquatint of Cambridge Botanic Garden, by J. Stadler after W. Westall, English, 1815

Wh.4510

In the decades around 1800 those standing adjacent to the hall of the Free School, now the main gallery of the Whipple Museum, and looking east across what is now the New Museums Site would have had a very different view. Rather than looking at the 19th and 20th century laboratories and museums, earlier spectators would have surveyed the original Cambridge Botanic Garden. This aquatint view was engraved by Joseph Constantine Stadler (*c.* 1755–1828) after an illustration by the artist William Westall (1781–1850) for the second volume of William Combe's *A History of the University of Cambridge* published for Rudolph Ackermann in 1815. When producing this illustration, Westall would have occupied a position towards the south end of the site adjacent to Pembroke Street, looking north towards Kings' College chapel and St Benet's Church, both of which are situated behind the greenhouses in this image.

Purchased by Dr Richard Walker in 1760 for £1,600, this land was conveyed to the university in 1762 with the view to establish 'a public Botanic of Physic garden'. The position of the greenhouses reflects the Linnaean design of the garden instituted by Professor Thomas Martyn (1735–1825), the third professor of botany, and Charles Miller (1739–1817) the first curator. In the early minutes for the garden, Martyn stated that it was 'absolutely necessary' that the plants should 'be ranged and marked according to the system of Linnaeus; and that a catalogue of them should be printed'. Different plants were arranged into Linnaean classes, orders, genera and species and the buildings, such as the greenhouses and museum, were positioned according to the guidelines Linnaeus stipulated in *Philosophia Botanica* (1751). This created the first Linnaean garden in Britain, a collection designed to be used alongside Martyn's course of botanical lectures. Decades later, Martyn remarked that his lectures 'were the first public notices of the Linnaean system' in the country.

Several curators managed the garden during Martyn's professorship, perhaps the most notable being James Donn (1758–1813), who augmented the

Garden's imperial networks to populate the collection with exotic plants gathered from across the British Empire. Drawn shortly after Donn's death, this view shows the garden at a turning point in its history: the Linnaean garden was already thought to be outdated and the site was deemed too small to accommodate the continual influx of species. Thus, the decision was made to move the botanic garden to its current site in 1846. The fact that this print was among the first acquisitions made by Liba at the Whipple Museum reflects a continued accessioning programme that connects the collection to the long scientific history of the site the Museum now inhabits.

Edwin Rose

Medals illustrating various scientific subjects, by E. Thomason, English, mid-19th century

Wh.4511

This set of sixteen Scientific and Philosophical Medals, each three inches in diameter, were sold with a magnifying glass in a book-shaped leather and velvet case. They were first advertised in 1829 by the Birmingham manufacturer, Edward Thomason. The son of a buckle manufacturer, Thomason had been apprenticed to Boulton & Co. at the Soho Foundry in 1785, before taking over his father's business and expanding to the manufacture of buttons, jewellery, cutlery, medals and other base and precious metal 'toys'.

In his memoirs, Thomason paid tribute to the 'scientific school of Soho', which had 'induced in me a versatility of taste for mechanism, and to cultivate the arts and sciences.' Inspired to 'produce novelty', he failed to convince the Admiralty with his steam-powered fire ship with mechanised steering, intended to attack the French fleet in harbour. Subsequent unprofitable patents, including for carriage steps and a gun lock, did not dampen his ambition. Success came with his 1802 patent for the 'Ne Plus Ultra Corkscrew'. Its mass production helped make his name and allowed him to develop the higher end of his business.

The medals celebrate this belief in the connection between scientific knowledge, engineering innovation and profitable industry. The improving tone of the medals, which form a little encyclopaedia, led *The Examiner* to call them an 'appropriate prize for scholars, or present for young people' but Thomason may have imagined them in drawing rooms and studies. Ever with an eye to promotion, he gifted a gold set to George IV and ones in white metal to men of science and noblemen. Their replies were included in his memoirs, including one, from the physician and educationalist George Birkbeck, which welcomed this 'metallic book of science'.

Twelve of the medals provide information on scientific disciplines and four form a potted history of steam power, culminating with James Watt,

whose ‘fame was now spread to the very skirts of civilization’. Most are text-only but there are illustrations on some, including the medal for Phrenology, which shows the classic head with numbered areas linked to particular traits. In the 1820-30s phrenology was popular and taken seriously by many men of science, including Birkbeck. Thomason had hosted their mutual acquaintance, the field’s pioneer Franz Josef Gall, when he visited Birmingham. Not all who received the medals approved, however. John Leslie, professor of natural philosophy at Edinburgh, asked ‘why did you admit Phrenology among the sciences? It should be placed beside Astrology, as only fit to occupy crazy old women.’

Though finely displayed in their case, the medals were not of high quality metal. Even with the magnifying glass, attempting to read them was, as *The Courier* complained, ‘very distressing to the eye’. This review and Leslie also noted several spelling mistakes. Such criticisms must have been distressing after the two years’ work that went into the medals’ production but seem to have prompted a reissue, requiring new dies. The Whipple’s set differs from the 1829 one in design and the use of block capitals. Many more Thomason corkscrews than medals were sold but enough were issued for examples to survive in other collections.* Celebratory of science and innovation, the medals were, above all, promotional of Thomason.

Rebekah Higgitt

* There are sets at the Science Museum, London (inv. nos. 1993-1363 and 1965-397), the History of Science Museum, Oxford (inv. no. 94849) and the Museum of Applied Arts & Sciences, Sydney, Australia (obj. no. N15832). Another copy of the Phrenology medal has been at the Whipple Museum since 1977 (Wh.2324).

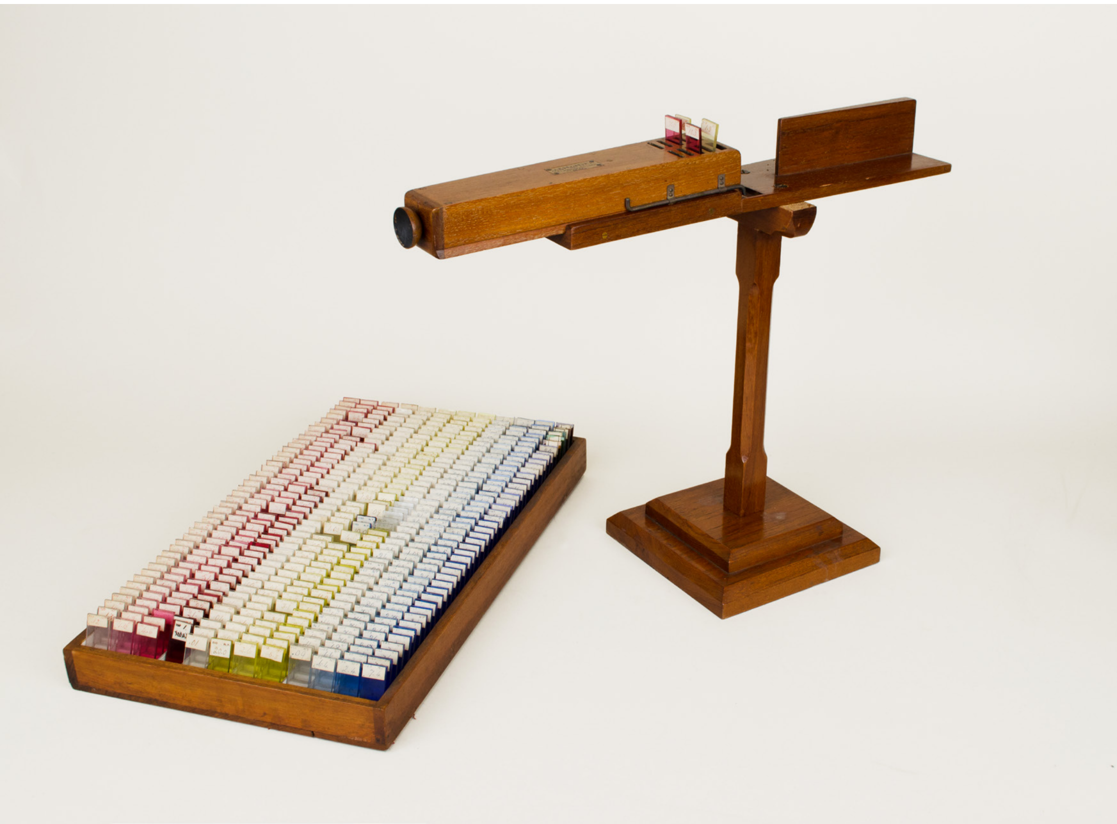
‘Tintometer’ colour comparator, by J. W. Lovibond Ltd, English, *c.* 1910

Wh.4521; T338

Joseph Williams Lovibond began developing the tintometer in the 1870s as a means to check the quality and consistency of the beer produced in his family’s breweries. Brown glass slides of varying shades are placed in the optical viewer and compared with a sample poured into the trough. From his experiments, Lovibond developed and patented his Series 52 scale of brown glass, which remains an industry measure for standardising the production of beer, whiskey, honey, and other brown liquids. Growing interest from a wide range of industries eventually led Lovibond to diversity the tintometer’s palette, allowing users to combine more than two hundred graduated hues of red, yellow, and blue to make a target colour for their product that could then be compared to a sample specimen.

Uptake by industry was swift, and Lovibond Tintometer Ltd exists to this day and continues to make colour comparison instruments.

Joshua Nall




.01
510 N.T.
20.0
2.6
.09
.64
2.4
7.4

Astrological astrolabe, possibly Germanic, 16th century*

Wh.4552

This astrolabe (diameter 124mm) is intended for astrological use, having no rete. It is made of copper with the surface gilded. The single plate is for 48°. It is possible that the instrument was produced early in the 16th century in the Germanic part of Europe.

Knowing the place of the Sun in the ecliptic, this instrument will show the hour, the time of sunrise and sunset. Similarly, when the position in the ecliptic of the planets is known calculations for the planets can be made. Using the alidade on the back, the hour may be found from the Sun knowing the day of the month, in either equal or unequal hours. The letters and numbers point to a date of manufacture at a transition point somewhere around 1500. The use of a curl above the lower-case 'u' is suggestive of Germanic manufacture. The single latitude of 48° precludes Spain and Italy, and leaves France and Germany. These towns are on or very close to this latitude: Strasbourg; Basel; Augsburg; Munich; Freiburg; Salzburg; Vienna.

An astrological astrolabe with a similar front and an ecliptic circle without star pointers, but rather larger (diameter 167mm) is in the Germanisches Nationalmuseum, Nuremberg. It is not signed, but is dated 1516 in the plain underside.† Another at Oxford with the same type of plate and an ecliptic ring of identical pattern is dated 1538 and bears the name of Johann Wagner of Nuremberg.‡

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* This account is extracted from a report by Gerard L'Estrange Turner written for the Whipple Museum in April 1996, shortly after the object was acquired.

† Inv. WI22: http://objektkatalog.gnm.de/objekt/WI22. Pictured and described in Gerhard Bott (ed.), *Focus Behaim Globus, Teil 2: Katalog* (Nuremberg: Germanisches Nationalmuseum, 1993), p. 592. Also illustrated in Ernst Zinner, *Deutsche und Niederländische Astronomische Instrumente des 11.–18. Jahrhunderts* (Munich: Beck, 1956), plate 25.

‡ Inv. 40443: https://www.hsm.ox.ac.uk/collections-online#/item/hsm-catalogue-2025. Pictured and described in Robert Gunther, *The Astrolabes of the World*, Vol. 2 (Oxford: Oxford University Press, 1932), No. 257, pp. 434–35, plate CVI.

A third similar example, but without the complete set of lines defining the unequal hours and Houses of Heaven, is in the Mathematisch-Physikalischer Salon, Dresden. It is not signed or dated, but is said to be made *c.* 1570, possibly by Hans Goebe.[§]

Gerard L'Estrange Turner (1926–2012)

§ Inv. TUE 6: https://skd-online-collection.skd.museum/Details/Index/50521. See Bott (ed.), *Focus Behaim Globus*, p. 611.

Gas (CO_2) laser, made in the Cambridge Department of Engineering, English, 1971

Wh.4560; Wh.4571

In 1971, lasers were novel and full of exciting potential. The first working lasers had been made in 1960, and carbon dioxide gas lasers, with their infrared beams invisible to the eye, were a particularly exciting development. They were the most powerful continuously operating lasers and could burn a hole in steel sheet. They brought reality to the ray guns of science fiction, and aspirations for future use in science fact in fields ranging from manufacturing to surgery.

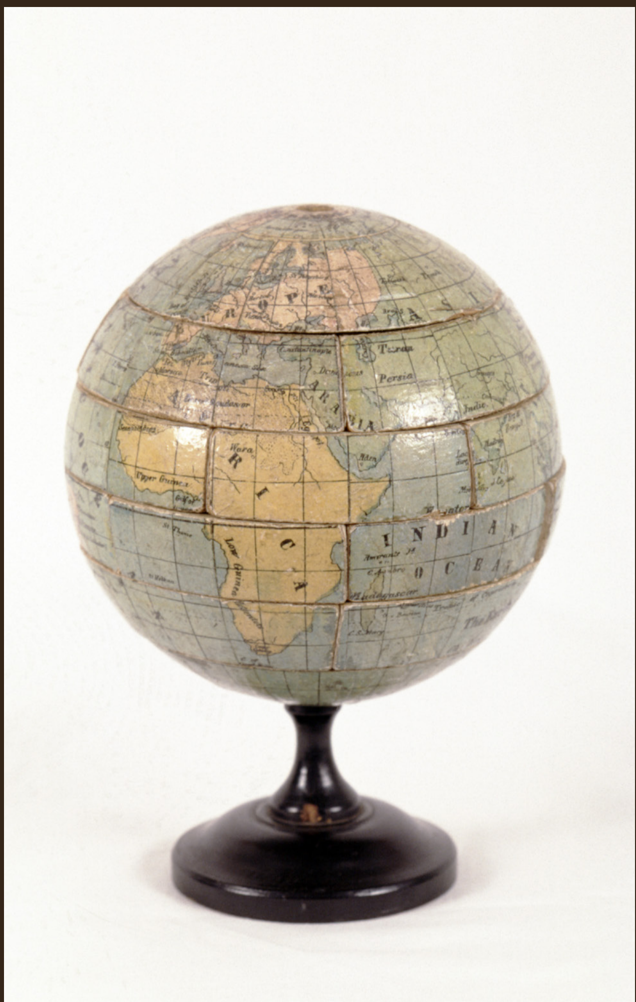
Compared to other lasers, the carbon dioxide laser was also accessible to build from available and affordable repurposed components. This one was made by students at the University of Cambridge's Department of Engineering, based on a design by Jeffrey Levatter, a high school student and future laser engineer, published in September 1971 in *Scientific American*. It was acquired by the Whipple Museum in 1996, where it sat centrally in the main gallery in prominent contrast to the older artefacts in lacquered brass and polished wood. It invokes the significant difference between using a piece of apparatus and building it for yourself and the understanding fostered by building and operating something cutting edge (literally) from basic components. It visually demonstrates the range of skills needed to successfully make this laser: glassware for the gas, vacuum pumps, electrical engineering and optics.

This laser, about as far from a trivial cat toy as it is possible to get, embodies both the continuation of the string and sealing wax tradition of making technical apparatus from available material, and the era of engineering equipment just before computer control and electronic chips ushered in the black box.

Tacye Phillipson


AMERICA


EUROPE.




Capricorn.
The Earth.
Ch. Kapp

5-inch terrestrial jigsaw puzzle globe, by Charles Kapp, German, *c.* 1875

Wh.4608

This colourful globe is a three-dimensional jigsaw puzzle with a didactic purpose. It is cut into six horizontal cross sections. The upper surface of each section has printed information about surface areas and population, and images, of the different continents. The lower surface shows maps of the continents. Each cross section, except for those at the poles, is divided into cake–like slices; the two on each side of the equator having six pieces, the other two having four pieces. By assembling the sections correctly, which encouraged the reading of the information they contained, the outer globe map was gradually constructed. In the section devoted to Europe, it is described as 'the smallest part of the world, but in consideration of its fertility industry and intelligence it is the first'. The image shows a small boy seated on a pile of books. He is reading a book which is perched on a globe. The rest of the image is crammed with symbols of progress and industry: a wheel, a ship, a beehive, a telescope, a chemical furnace and an artist's palette. The implication is that Europe is superior to other parts of the world, a view prevalent at the time, its superiority being based on knowledge and education. The images depicting the other continents are less elaborate and give a very simplistic idea of foreign, exotic places. Asia is described as the second part of the world and the image depicts a sultan-like figure riding on an elephant. Africa is the third part of the world and shows a native hunting a lion with a bow and arrow. America is fourth and the image depicts a ship and a few native animals and birds. Australia is fifth and shows two colourfully attired indigenous people and a volcano.

Geography was part of mainstream education in Europe in the 19th century and dissected map puzzles like this one were popular as they made learning fun. Similar globes were made by several other artisans. Few complete puzzle globes survive as the pieces were easily lost.

Sylvia Sumira

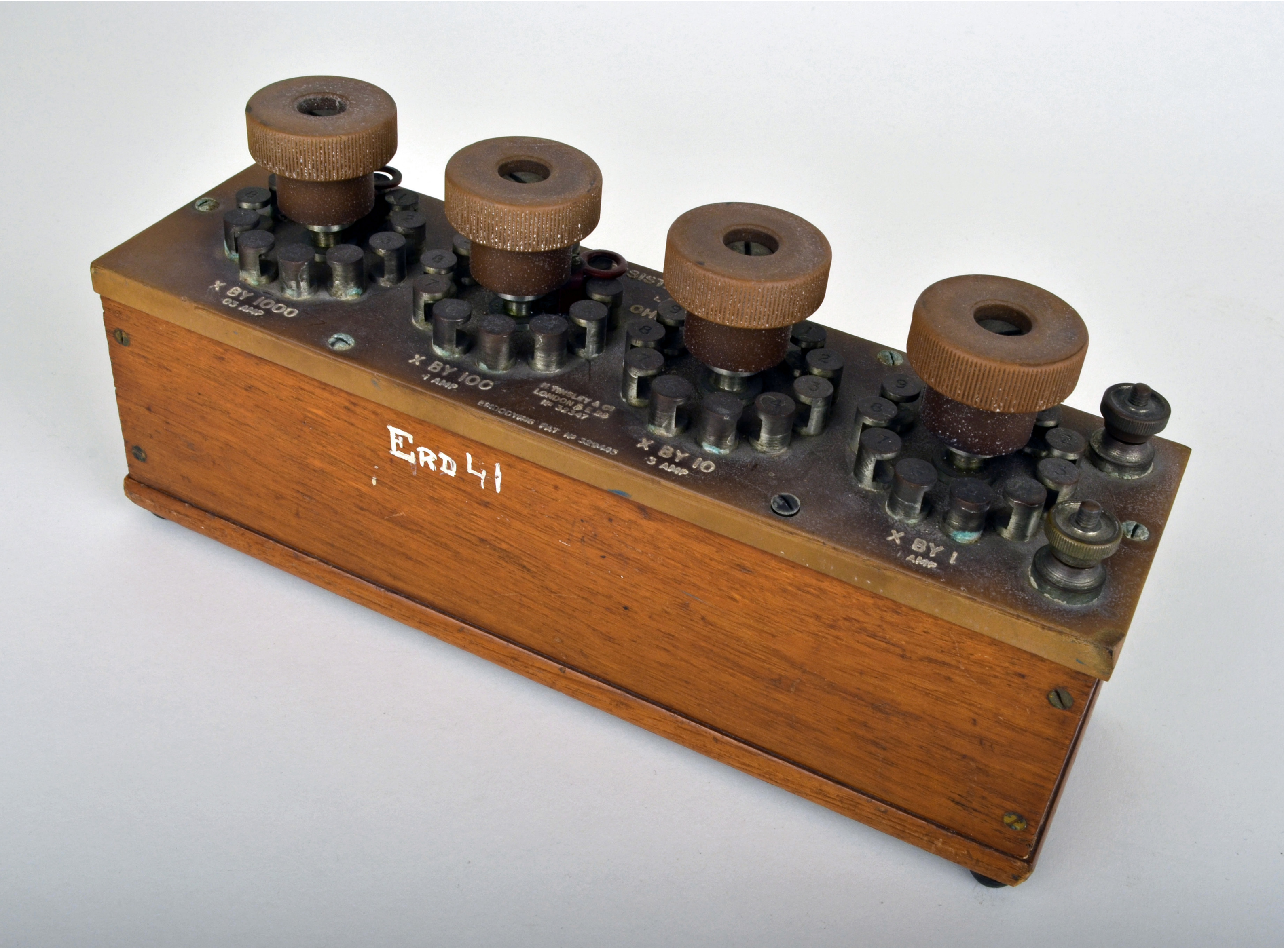
Decade resistance box, by H. Tinsley & Co., English, early 20th century

T158

The Whipple Collection is rich in instruments from the early 20th century, a period that saw the benchtop black box come of age. This resistance box captures the process part way through. Its Bakelite dials offer tantalising clues to the inner workings; as the user turns them to select units, tens, hundreds or thousands of ohms of resistance, they can see brushes sweeping from contact to contact. But despite the clues, the mechanisms are hidden: inside the box are a series of carefully wound wire coils of various lengths, each presenting a known resistance to an unvarying electrical current. However, the physical workings only tell part of the story. Like so many instruments in the Whipple Collection, the box captures a theoretical concept, making it into a material thing that can be held, neatly packaged and sold as a commodity.

This object, T158, also provides a clue to the inner workings of the Whipple Museum. Here, the 'T' stands for temporary number. Anybody who works with museum collections will be familiar with objects that are catalogued with little provenance and marked as 'found in museum'. Sometimes those objects' origins are rediscovered, other times their temporary designation becomes their permanent one. Soon after joining the Whipple Museum in 1995, Liba introduced the T-numbering system to help record orphaned objects. T158 may have arrived at the Whipple well before Liba, however it only officially began its life as a catalogued part of the collection when it was given its new T-number identity in July 1997.

Charlotte Connelly


X BY 1000
X BY 100
1 AMP
X BY 10
3 AMP
X BY 1
ERD 41

Mathematical string model, by Martin Schilling, German, late 19th century

Wh.5175

On the top of Wh.5175 – a metal frame on which pieces of coloured string are stretched out, forming an intricate pattern of lines – sits a label: '18. Serie nr. 1, Regelfläche 3. Ordnung, 1. Fall' [18th series no. 1, ruled surface third order, first case]. It also mentions the name Martin Schilling.

Martin Schilling was a publisher who in 1911 released the seventh edition of his catalogue advertising a wide range of physical objects (i.e. three-dimensional models) representing various mathematical objects.* aThe 18th series in Schilling's catalogue consists of four string models of ruled surfaces of the third order, constructed under the supervision of one Christian Wiener at the Technical University in Karlsruhe. The first case in this series (of which Wh.5175 is a copy) was published in 1891 and is a smaller version of a similar model constructed in 1882–83.

A ruled surface is a geometrical object that can be defined by the movement of a straight line. It is thus natural to represent them via tightly stretched pieces of string. The practice of constructing such models originated with Gaspard Monge at the École Polytechnique in Paris, where he taught 1794–1809, and his student Théodore Olivier. From there the trend seems to have spread to other countries, reaching its peak in Germany by the late 19th century.

Particularly influential among the German modellers were Alexander Brill and Felix Klein, both of whom took up positions in 1875 at the Technical University in Munich. According to Brill,† their first priority upon

arriving was to negotiate funds from the Bavarian government to establish

* Martin Schilling, *Catalog Mathematischer Modelle für den Höheren Mathematischen Unterricht* (Leipzig: Martin Schilling, 1911).

† Alexander Brill, 'Über die Modellsamlungen des Mathematischen Seminars der Universität Tübingen', *Mathematisch-Naturwissenschaftlichen Mitteilungen* 2 (1887) pp. 69–80.

a workshop as part of the mathematical seminar, where modelling exercises came to form part of the curriculum. Some of the resulting models would in turn be reproduced and sold by Ludwig Brill, Alexander's brother, through his company in Darmstadt. This was the company Martin Schilling bought in 1899.

Wiener himself was professor of descriptive geometry in Karlsruhe from 1852 to his death in 1896. He was connected to the German modelling community in several ways – he was for example the uncle of the Brill brothers – but model-building also played a more direct role in his career. Particularly famous was his plaster model of a non-singular cubic surface with twenty-seven real lines. Constructed in 1868 and publicised through a small book with stereoscopic images,‡ many contemporary mathematicians considered it a significant achievement. For instance, the London mathematician Joseph Sylvester included Wiener's model among the discoveries which 'must for ever make 1869 stand out in the Fasti of Science'.§

That Wiener, whose studies had been in architecture, construction, and mechanical engineering, could make his name as a mathematician in this way illustrates the status these models enjoyed in the mathematical community at the time.

Rune Nyrup

‡ Christian Wiener, *Stereoscopische Photographien des Modelles einer Fläche dritter Ordnung mit 27 reellen Geraden: mit erläuterndem Texte* (Leipzig: Teubner, 1869).
§ Joseph Sylvester, 'Outline Trace of the Theory of Reducible Cyclodes', *Proceedings of the London Mathematical Society* 2 (1867), pp. 137–60.

8-inch celestial astrologer's globe, Indian, 19th century

Wh.5180

THIS BRASS CELESTIAL GLOBE is extremely unusual in being inscribed in a mixture of Arabic, Persian and Urdu, representing a blending of traditions. It originated from north-central India and appears to have been designed for astrological use. Small embossed figures are used to represent the zodiacal constellations, and the numerous inscriptions on the globe include information on, among other things: the zodiacal houses; unlucky days of the month; dejections of the planets and stability of the zodiacal signs; exaltations and detriments of the planets; and the names of angels.

The Editors

Three-draw spyglass, English, 19th century

HC04

This spyglass is always a favourite when children are working with the Museum's handling collection. One of the reasons that it's so interesting and such a good teaching tool is that we know so little about it. We can see that it's very small (36mm x 33mm when closed), designed to be held in a hand or a pocket, and that it's made from brass and tortoiseshell. We know that such spyglasses were popular in the 19th century, so the object is dated between 1800 and 1900 but no more precisely than that. Despite this lack of information about the object itself, it forms a valuable part of the handling collection because it is such a pleasure to interact with; the three-draw tube still extends and contracts beautifully and you can still look through it and see how it works (even, as we have discovered throughout 2020, when you hold one end of it up to a webcam for an appropriately distant audience). Liba's understanding of the importance of being able to explore objects in this way has been crucial to the establishment and growth of the handling collection, which in turn has allowed new generations of children to learn more about the history of science.

Alison Giles

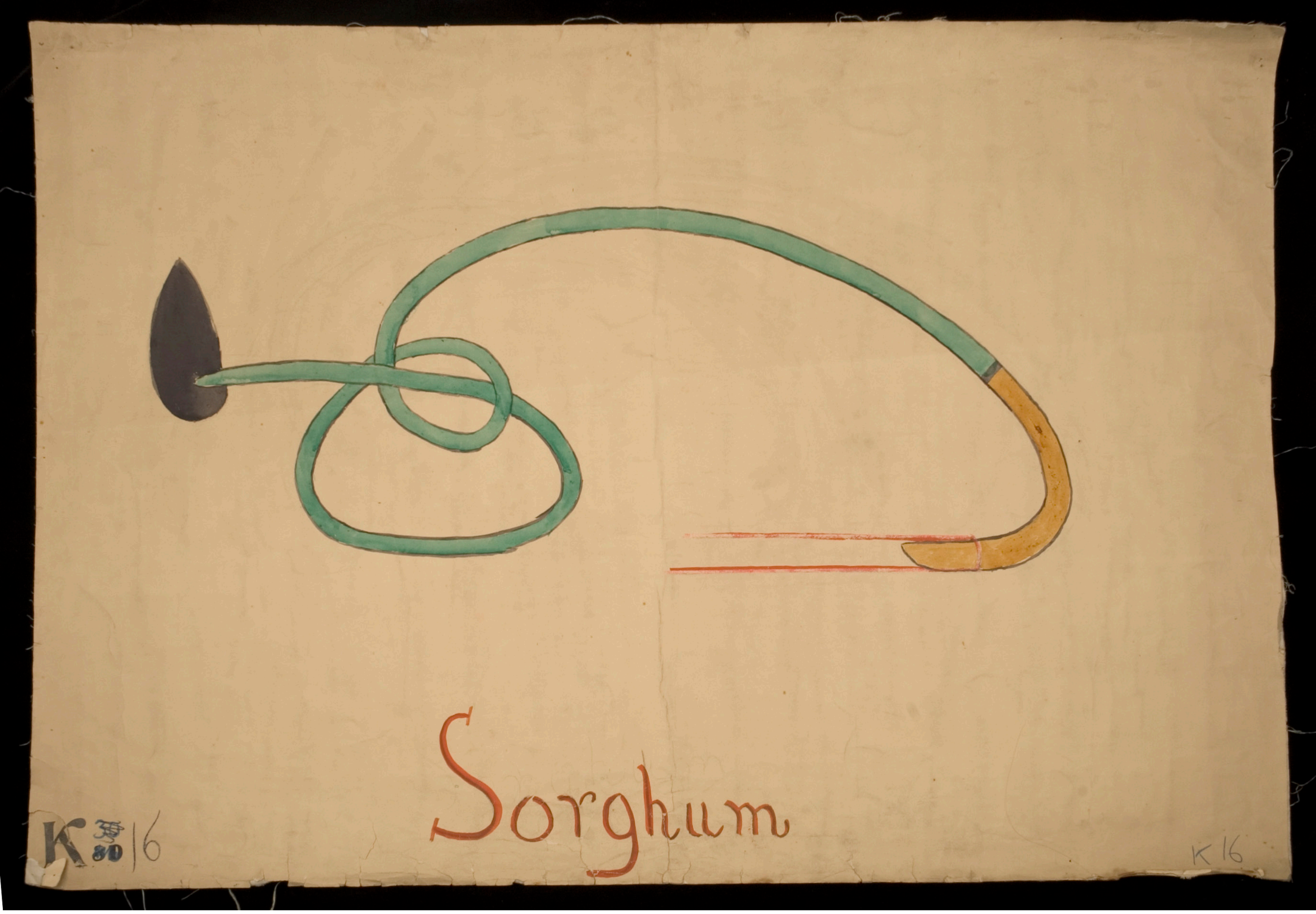
Botanical wallchart showing geotropism in a Sorghum seedling, by Francis Darwin, English, *c.* 1900

Wh.5456

Francis Darwin used wallcharts to illustrate his lectures on physiological botany at Cambridge from 1884 to 1903. His interest in the subject had been sparked by working as his father's assistant from 1874, and he collaborated closely on Charles Darwin's last botanical work *The Power of Movement in Plants* (1880). One of the phenomena the Darwins investigated was 'geotropism', the directional movement of plants in response to gravity, with some parts (roots) responding positively and others (stems) negatively. Their work resulted in the major discovery that the 'gravitation-sense' of plants resided only in the tips of the primary roots. They satisfied themselves that this was the case by simply cutting off these tips. However, their demonstration did not satisfy critics who argued that the lack of response to gravity by the remaining part of the root was more likely the result of trauma to delicate plant tissues than the absence of gravity-sensing organs.

It was 14 years later (and 12 years after Charles Darwin's death) that the brilliant botanist Wilhelm Pfeffer provided the 'long-hoped-for proof that the tip of the root is a sense-organ for gravitation'. This led Francis Darwin to declare of his and his father's work: 'Our method of proof does not hold good, but our conclusions are true after all.' Pfeffer tricked the plant. He forced the root to grow in a minute 'glass boot', which kept the tip at right angles to the rest of the root. When the glass was positioned so the tip pointed downwards, there was no geotropic reaction and the remaining part of the root continued to grow horizontally, but when the tip was horizontal, the main body of the root pointing vertically down began to curve. This demonstrated that gravity was perceived exclusively in the tip of the root.

Pfeffer's experiment led Francis Darwin to 'hit on' another mode of demonstration. His method was based on the 'inverted action familiarly known as the tail wagging the dog', and the experiment entirely changed the character of the geotropic movement. Usually, the seed and shoot were



held horizontal, in which case geotropism caused the embryonic root to bend until the tip pointed vertically downwards. In Darwin's experiment the tip was held horizontal. This resulted in a continuous bending movement of the stem because the tip stimulated a geotropic reaction for as long as it was not vertical.

A 'shock of delight' was experienced by Darwin when his surprised laboratory assistant reported that the Sorghum seedlings in the experiment had 'curled up like corkscrews'. However, as the wallchart pictured here shows, the musically-minded Darwin (he played the flute and the bassoon) preferred to illustrate the phenomenon in his lectures with those seedlings that more closely resembled a 'French horn'.*

Anne Secord

* All quotations are from Francis Darwin, 'The Movement of Plants' (first published in *Nature*, 14 Nov. 1901, pp. 40–44) and 'Picturesque Experiments' in *Rustic Sounds* (London: John Murray, 1917).

5-inch refracting telescope on an equatorial stand, with clockwork drive, ‘Royal Century’ model, by W. Watson & Son, English, *c.* 1908

Wh.5612

An object acquired to celebrate the turning of the Millennium, it has greeted visitors to the Museum ever since. Purchased from Trevor Philip & Son Ltd with grant aid from the PRISM fund, this telescope was one of the first of Liba’s ‘marquee’ acquisitions and as an object represents a rare cross-over between the needs of a museum collection and the taste of a dealer – it is an imposing architectural piece and draws the visitor into the gallery. Testament to this is the level of wear to the eyepiece from visitors hoping to catch a glimpse of (something?) through the lens.

The ‘Royal Century’ was Watson’s most elaborate and expensive model. Like professional observatory telescopes, this model sat on a clockwork-driven equatorial mount designed to move the telescope in precise opposition to the Earth’s rotation, holding the object of study steadily within the field of view. Priced at a very costly £170, the instrument was likely designed both for wealthy home observers as well as scientific enterprises such as land surveys and remote expeditions, where a precise but portable telescope would be ideal.

James Hyslop


discover

Fume cupboard made for Newnham College, used by Ida Freund for teaching chemistry, English, late 19th century

Wh.5616

A quintessential Liba acquisition. This fume cupboard was constructed for use in the chemistry laboratory at Newnham College, a practical teaching space founded in the 1870s for the education of women. At the turn of the 20th century, women were not admitted to the University Chemistry Laboratory until they had passed Part 1 of the tripos. The laboratory at Newnham College provided female students with the opportunity to study for this exam under the guidance of Ida Freund – the first female chemistry lecturer in Britain. Freund eventually published her laboratory teaching programme in the influential 1904 textbook, *The Study of Chemical Composition: An Account of its Method and Historical Development with Illustrative Quotations*. Studying this text now, we can see how students at Newnham conducted chemical experiments not only to pass exams, but also to practice rigorous logical thinking and to learn to question their own assumptions.

By the 1910s, female students began to gain acceptance in expanded University teaching spaces and, following Freund's retirement in 1913, the Newnham lab fell into disuse. Used as a storage space for much of the century, it was eventually redevelopment as a performing arts centre in 1998. Remarkably, a pair of fume cupboards had remained in situ, undisturbed for eighty-five years. Liba, upon hearing of this rare survival on the grounds of her own college, immediately arranged for one of the pair to be extracted and moved to the Whipple Museum, to preserve an important artefact of Cambridge scientific education.

Joshua Nall

11-inch manuscript celestial globe, Japanese, 1784

Wh.5617

When stargazers looked up at the night sky from Northeast Asia, they saw many of the same stars that Europeans saw. Both imagined connections among specific stars, and gave those assemblages fanciful names. Both tracked the ecliptic, the yearly path of the Sun around the sky, and admired the spangled band of the Milky Way, illustrated here with flakes of gold leaf. Both, also, created celestial globes to represent what they saw.

As this example from 18th-century Japan shows, however, East Asian celestial globes represented the heavens in distinctly different ways from European ones. First of all, they grouped the stars differently. The asterisms on this globe are less elaborate than the constellations of European star maps, sometimes consisting of just two or three linked stars. Where Europeans saw chained maidens, hunting dogs, and air pumps, East Asian astronomers saw imperial concubines, heavenly fields, and celestial officials. Even when the asterisms' names fire the imagination, their appearance does not; all the stars on this globe are dots of uniform scale linked by straight lines, with the name of each asterism written alongside it. There are no fanciful illustrations of animals or mythological figures, and the globe's creator has not distinguished larger stars from smaller ones, as was typical on instruments in the Western tradition.

What the Japanese globe maker prioritized, instead, was the human connection with the stars – the history of discovery. The inscription at the bottom indicates that the different colors of the asterisms, inked in red, green, yellow, and black, represent the astronomer who first observed them. All but the green ones represent Chinese astronomers. Just as Japanese scholars adopted from China the script that graces the globe's surface, they also adopted the Chinese canonical sky, which was supposedly – the attribution is apocryphal – delineated by three astronomers sometime between the 3rd millennium and the 3rd century BCE.

The unknown instrument maker departed from his predecessors in some ways, however. The green asterisms are his own additions, based either on his observations or those of a contemporary astronomer. The stars depicted as open rather than colored-in circles are 'stars once visible that now cannot be seen', implying that knowledge, or the sky, or both changed over time. One element of new knowledge that did not impact this globe, however, was European developments in astronomy: stars in the southern celestial hemisphere that the Jesuits had observed do not appear here. This reflects Japan's political isolation at the time. Since the early 1600s Japan had been a 'closed country' that strictly limited contact between its own people and foreigners.

Most extant celestial globes from East Asia are made of engraved metal, not wood, paper and plaster as this one is. Was it used as a model for a more permanent instrument? Was it used for teaching? We cannot be sure. Despite its modest materials, this globe's simple elegance has enabled it to be preserved for over two hundred years.

Hilary A. Smith


SPHERE
MOGG'S
Published Novr. 1st. 1812 by EDWd. MOGG.
No. 51 Charing Crofs.
JANUARY FEBRUARY
APRIL
Orion
Sun

Dissected card terrestrial globe, by Mrs. Johnstone, English, 1812

Wh.5619

Dissected card celestial sphere, by Edward Mogg, English, 1813

Wh.5620

These card globes were published as educational aids for children. Students were expected to build and rebuild them, learning about the structure of the earth and heavens as they went. Research conducted in the Whipple Museum suggests that conversation would also have been an important aspect of their use. Students would be encouraged to talk through the parts of the globes with a teacher, preparing them for polite astronomical discourse around larger instruments in later life.*

The Editors

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* Katie Taylor, 'Mogg's Celestial Sphere (1813): The Construction of Polite Astronomy', *Studies in History and Philosophy of Science* 40 (2009), pp. 360–71.

Papier-mâché model of a black mulberry, by Auzoux, French, late 19th century

Wh.5765

This beautiful piece caught my eye the first time I walked into the Whipple Museum in 2008. Very bottom shelf and on the left. Plump, purple, almost ripe enough to eat, this mulberry (*morus nigra*) model fascinated me from the beginning. Auzoux's collection of plant models is richly detailed and bigger than life. This piece was the first of Auzoux's botanical collection acquired for display at the Whipple Museum in 1998 and is part of a unique collection of teaching instruments created by Louis Thomas Jérôme Auzoux (1797–1880).

In early 19th century Paris, medical training shifted from an intuitive and dogmatic approach to an empiric model that emphasized experiment and observation. The autopsy was central to this curriculum. This new method attracted many learners to Paris and resulted in a shortage of human specimens for study. Auzoux identified this pedagogical gap and designed reusable papier-mâché models of human anatomy that could be used in lieu of real cadavers. He ultimately transformed his invention into a commercial success and international educational empire. Botanical models were added to this collection in the 1860s.

Auzoux devised a specialized carton paste for his creations composed of flour glue, finely shredded paper, chopped rags, oakum, calcium carbonate (blanc de Meudon) and powdered cork (poudre de Liège). It was highly malleable when wet and hardened as it dried so that it retained whatever shape it had been given – unlike wooden models, which were more likely to distort and warp. Its organic nature contributed to the life-like feel of the models and made them more realistic to the touch. An additional distinctive feature of Auzoux's teaching models was their ability to be taken apart and replaced as in a real dissection. Fully functioning hooks and attachments enabled the user to remove body parts and delve deeper into the human, animal, or plant structure.

Studying Auzoux's objects and how they fit within 19th-century scientific and medical teaching highlights how objects could be used to promote different agendas. Auzoux's botanical collection was purchased by many institutions of higher learning across the world, and in each setting it was given distinctive meanings. At Cornell University in the United States, for example, the models were aspirational objects purchased to establish Cornell as a reputable institution with an enviable scientific curriculum. At Mount Holyoke College, the botanical collection was a gift from a male donor and thus implicated the models as gendered objects.

As scientific objects, Auzoux's models did more than simply represent plants and teach botany. They reinvented themselves in each new setting they were placed and shifted meanings within these settings. The possibility of inserting them into different social environments to achieve varied objectives highlights the potential for the diffusion of scientific objects across multiple domains.

Margaret Olszewski

Electro-galvanic machine, by Horne, Thornwaite, & Wood, English, *c.* 1850

Wh.5813

The use of electricity, or galvanism, for medical purposes had attracted interest in the mid-18th century, but it was not until the 1840s and 1850s that it started to become popular, being recommended for a very wide range of illnesses and conditions and attracting quack practitioners. This trend is reflected in the headings used in the Post Office London Directories, the term 'Medical Galvanist' not appearing in the 1840 edition but having two entries by 1845 and four by the early 1850s. Horne, Thornthwaite and Wood began their business in 1844 and were primarily known as opticians, supplying telescopes and other optical instruments, but they also sold electro-galvanic machines for medical purposes. On 15 March 1845 their advertisement appeared in the *Illustrated London News* (p. 175) offering 'portable electro-galvanic machines' to those afflicted with 'Rheumatism, Sciatica, Tic-douloureux, and all Nervous Affections, being so extremely simple that they may be used by the patient themselves without trouble. Complete, with directions, £3 3s'. This price was equivalent to the weekly wage of a commercial clerk, so could only be afforded by the well-off.

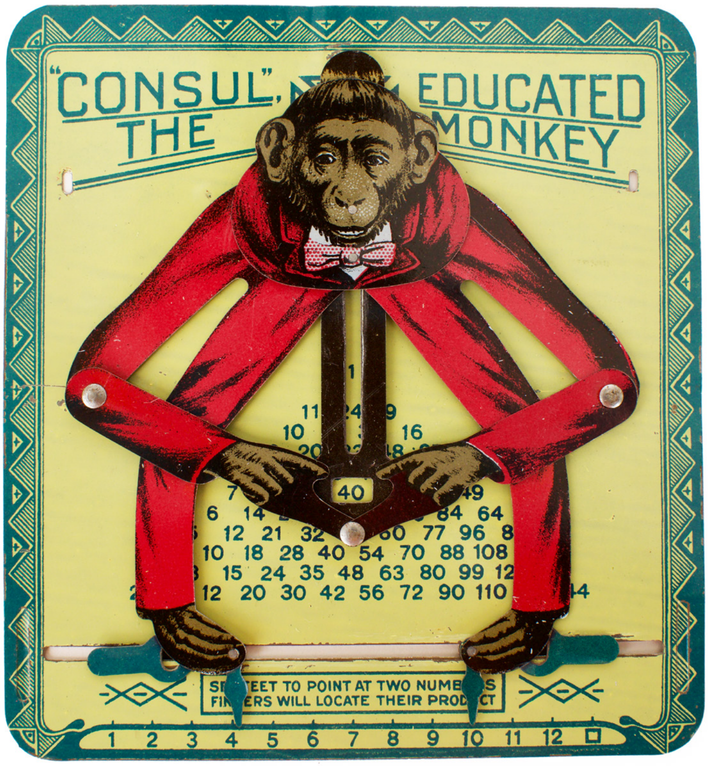
This particular object is useful for research purposes because it gives the address of the makers, which enables the machine to be dated, and includes detailed instructions pasted into the lid. Horne, Thorthwaite & Wood had their shop at 123 Newgate Street in the City of London between 1844 and 1854. In 1854 Edward George Wood left the partnership and although he later rejoined, by then the firm was trading from 416 Strand, placing the date of the Whipple Museum's instrument around 1850. The instructions with the machine indicate that Horne, Thorthwaite and Wood were successors to another London instrument maker, Edward Palmer, and an advertisement in *The Athenæum* of 21 September 1844 indicated that all three partners had worked for Palmer and had acquired most of his tools and stock. In addition to the ailments mentioned in their advertisement the instructions suggested that the machine was also helpful for liver complaints and paralysis. But reading the instructions for use undermine the claim that it was extremely simple and illustrates the very basic level of battery technology at that date. This helps to explain why a group of medical galvanists emerged to administer treatment with electro-galvanic machines.

Gloria Clifton

‘Consul, the Educated Monkey’, mechanical calculating device, by Tep Manufacturing Co., American, *c.* 1920

Wh.5821

This colorful metal teaching device well represents the rise of relatively inexpensive children’s toys, mathematical instruments, mathematical teaching apparatus, and general consumer goods that occurred in the United States around 1900. It was patented in 1915 by a Texas-born former mathematics teacher named Henry William Robertson, who was then working for cash register manufacturer NCR in Dayton, Ohio. The mathematical table has moveable feet along the bottom for setting up multiplication and addition problems and swinging arms that point out the answer. The device was trademarked as Consul, and sold as Consul the Educated Monkey. The story of the instrument is available from several sources, many now available online.



Consul the Educated Monkey – especially the example in the Whipple collections – represents a range of transatlantic interchanges which merits comment here. The toy is named for a performing animal, trained in England. In 1909, the monkey sailed from Britain to the United States, where it performed across the country – visiting Dayton and NCR in 1910. American-born movie producer Charles Urban, who worked out of London, produced a short comic film about Consul’s journey entitled *Consul Crosses the Atlantic*. It circulated from 1909 until at least 1915. Robertson was not yet in Dayton when Consul visited there, but Consul’s journey undoubtedly influenced the name he gave to his invention.

Eighty years after Robertson's patent, American Liba Taub crossed the Atlantic to assume the position of Curator at the Whipple Museum of the History of Science in Cambridge. In 2000, the Whipple purchased its example of Consul from an American dealer. It too crossed the sea and soon was on exhibit. In 2008, another American, Caitlin Wylie, came to Cambridge for graduate studies, writing her Master's dissertation on the object the following year. This work was duly published by the Whipple in 2012, with further modifications in 2019.[*] Wylie herself completed her doctorate and returned to the United States to pursue an academic career.

In 2015, the mathematics collections at the Smithsonian's National Museum of American History (NMAH) received as a donation an example of Consul the Educated Monkey. That same year, Peggy Kidwell, the curator responsible for the object, visited the Whipple to study its outstanding collection of trade literature on electronic calculators. Liba Taub, Joshua Nall, and their colleagues provided wonderful access to materials on this subject. Kidwell also browsed the exhibits, spotted the Whipple's example of Consul, and learned of Wylie's work. On her return to the United States, she combines these sources and other materials to write a blog on Consul for the NMAH website,[†] as well as a description for the Museum's online catalog.

This year, Whipple staff asked Kidwell to prepare an account of an object in its wonderful collections. Good historical accounts of Consul the Educated Monkey are already available, but these transatlantic musings seemed appropriate.

Peggy Kidwell

* Caitlin Donahue Wylie, 'What "Consul, the Educated Monkey" Can Teach Us about Early-Twentieth-Century Mathematics, Learning, and Vaudeville', in Joshua Nall, Liba Taub, and Frances Willmoth (eds.), *The Whipple Museum of the History of Science: Objects and Investigations, to Celebrate the 75th Anniversary of R. S. Whipple's Gift to the University of Cambridge* (Cambridge: Cambridge University Press, 2019), pp. 237–56.

† Peggy A. Kidwell, 'Consul the Educated Monkey, or the inventions of William H. Robertson', *Oh Say Can You See? Stories from the Museum,* Smithsonian National Museum of American History blog, 29 Jun. 2015: https://americanhistory.si.edu/blog/consul-educated-monkey-or-inventions-william-h-robertson.

Horary quadrant, paper on brass, by Henry Sutton, English, 1658

Wh.5831

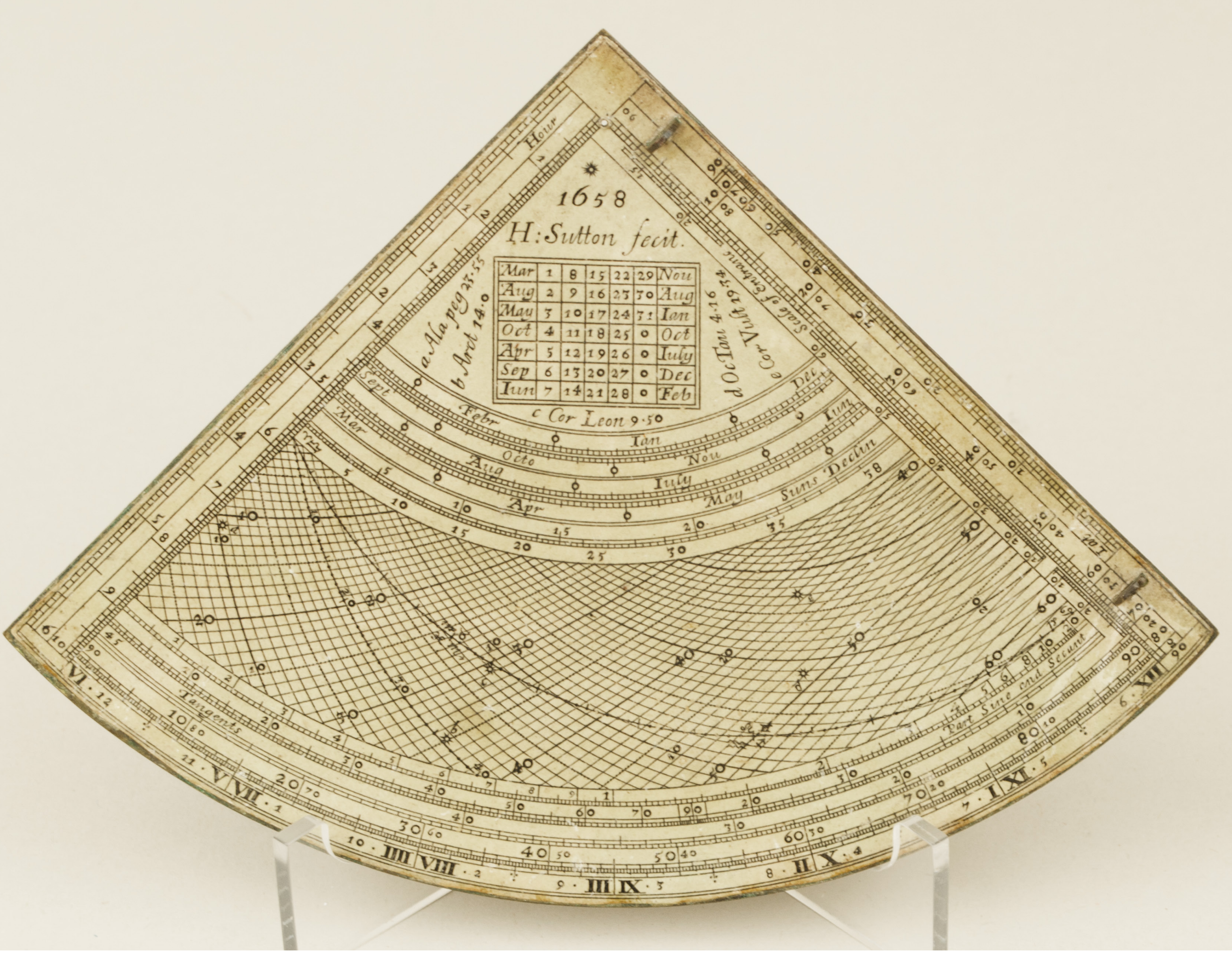
Of the many treasures that passed through our gallery on Jermyn Street, Liba was always able to pick out those that would fit best into the Whipple collection, and it was always a pleasure to learn of students then making further study of them. We were proud to be sponsors between 1997 and 2016 of the Waterman Prize for an outstanding performance on an essay based on an object in the Whipple Museum's collection.

As a collector Liba had a great eye for a fine instrument. We agree fully with Edmond Stone's declaration in 1758 that

> Mr Sutton's Quadrants, made above one hundred Years ago, are the finest divided Instruments in the World; and the Regularity and Exactness of the vast Number of Circles drawn upon them is highly delightful to behold.

Two of the fourteen Sutton instruments now at the Museum came from us, and more of his works can now be seen at the Whipple than at any other time or place since the mid-17th century, when Sutton had his workshop behind the Royal Exchange.

Saf Waterman

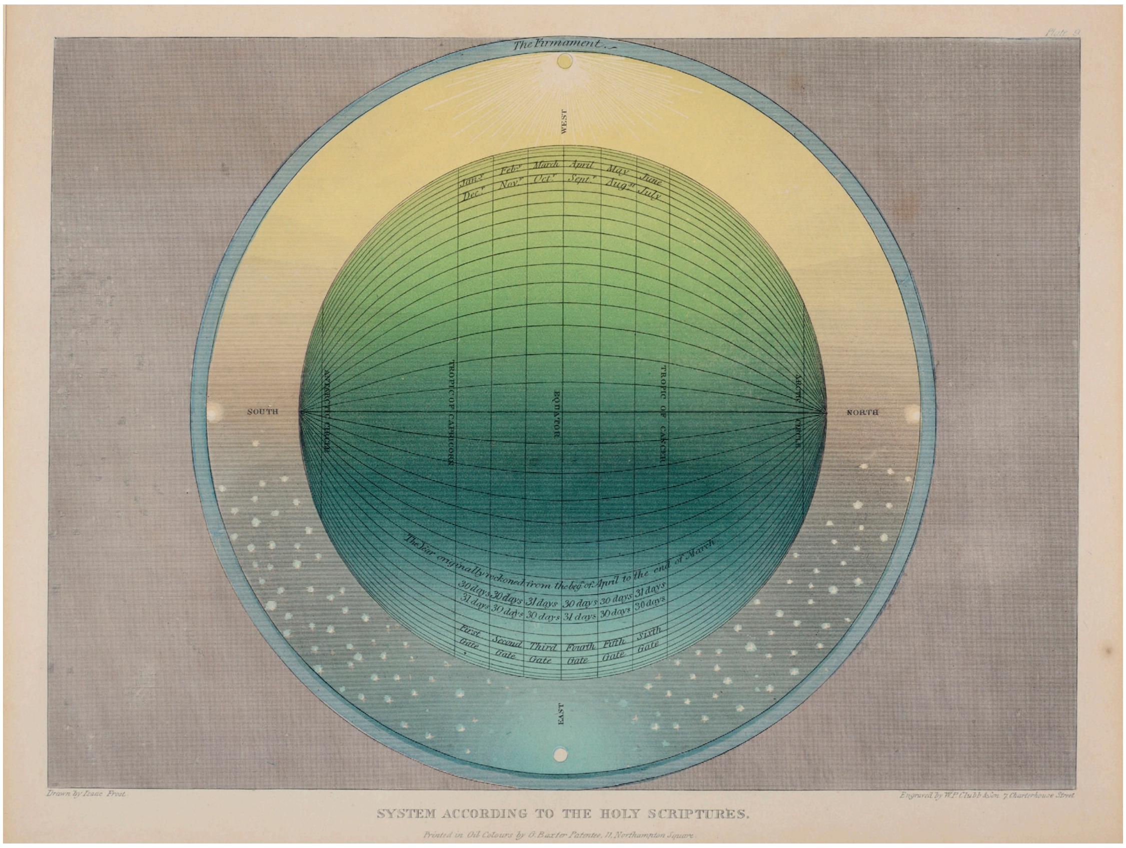

1658
H:Sutton fecit.
c Cor Leon 9.50
Suns Declin
Tangents

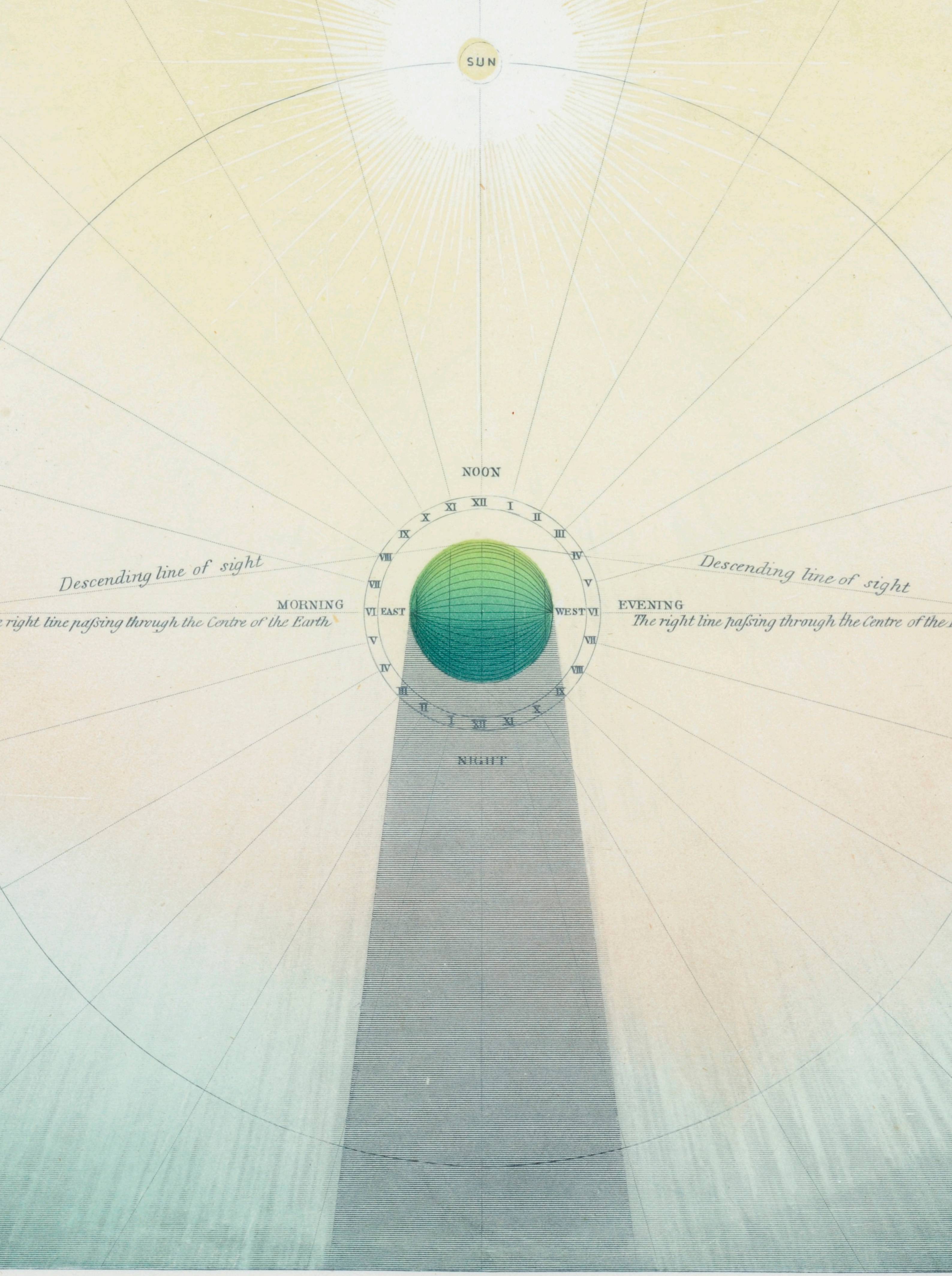
Muggletonian astronomical prints, drawn by Isaac Frost and printed by George Baxter, English, 1846

Wh.5857

These prints were included as plates in Isaac Frost's *Two Systems of Astronomy* (1846). This book attacked the orthodoxy of heliocentric Newtonian astronomy and presented instead a rival system of the universe based on a particular and literal reading of the Bible. Frost was a member of a small Protestant sect, the Muggletonians, who believed the Earth was stationary and that Heaven existed as a physical reality. Three of these illustrations aim to demonstrate flaws in 'The Newtonian System' of describing the cosmos; the other three illustrate the Muggletonians' own 'System According to the Holy Scriptures'. Essential for conveying Frost's argument, the plates were handsomely produced by London's leading colour printer, George Baxter, and their extravagant cost required that the book's publication be subsidized.

Joshua Nall





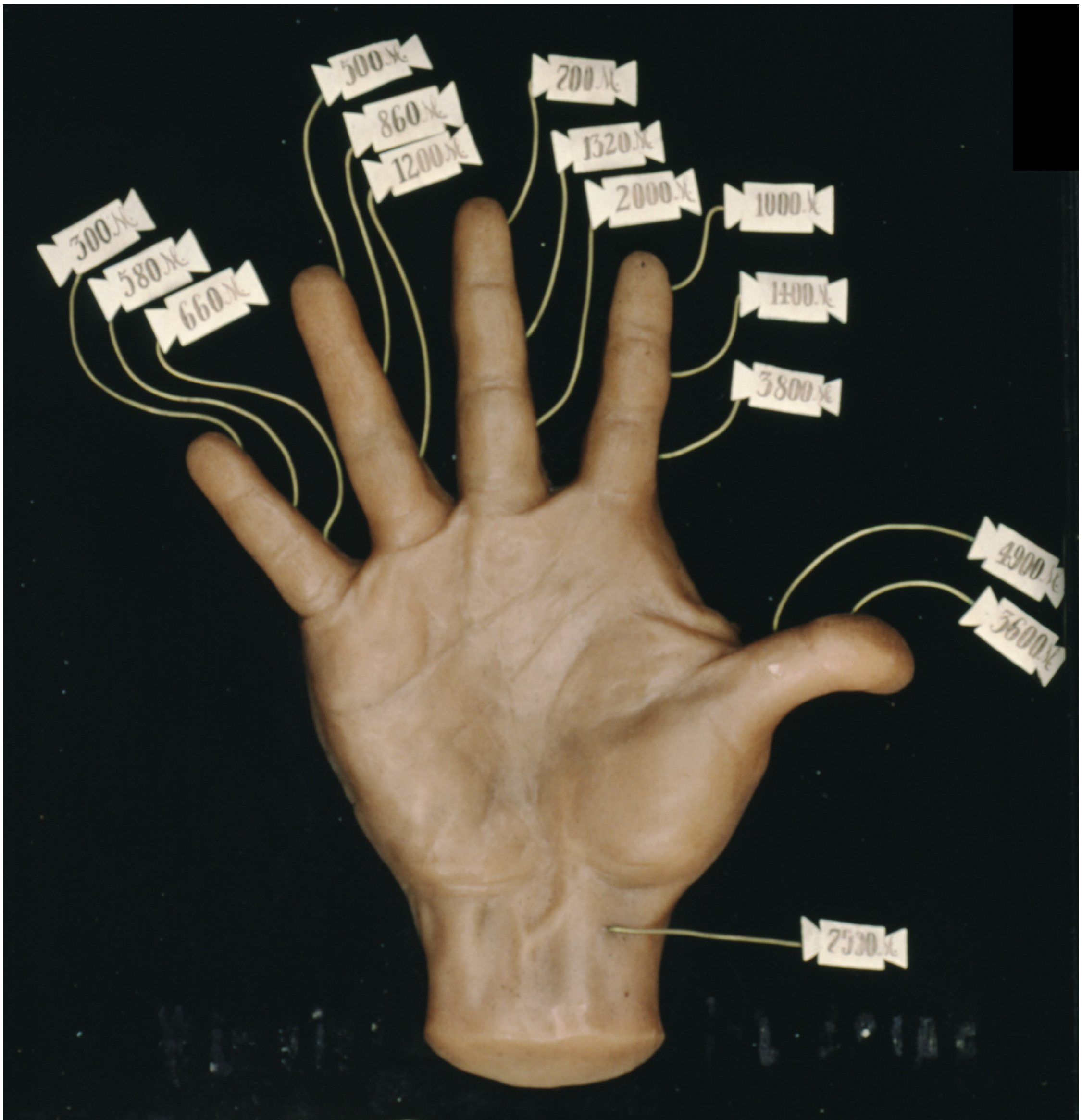
SYSTEM ACCORDING TO THE HOLY SCRIPTURES.

Model of a human hand, labelled with compensation values awarded for the loss of digits or limbs in industrial accidents, German, mid-20th century

Wh.5862

This anatomical model illustrates the amounts of compensation that insurance companies and courts of law would pay out for the loss of digits or limbs in industrial accidents. The amounts are listed in the old German currency: Deutsche Marks. The loss of the entire hand was valued at 7,000 Marks; the loss of a thumb was listed at 4,900 Marks. The tip of the little finger, however, was worth the least – for its loss, the plaintiff could only claim 300 Marks.

The Editors



Prototype rock compass, comprising a theodolite by DEP, adapted by Brian Harland, Canadian and English, *c.* 1957

Wh.5903

Arctic geologist Brian Harland adapted this theodolite for use in the field to measure the orientation of rock specimens. Harland subsequently published the design and rock compasses entered commercial production for use in palaeomagnetic studies. In 2003 the Whipple Museum accepted by donation the Brian Harland Collection, comprising a range of instruments, tools, and equipment used by Harland and his students during a lifetime of field work, most notably Harland's exhaustive geological survey of the island of Svalbard conducted between 1949 and 1993.

The Editors

Rojas-type universal altitude dial, probably Spanish Netherlands, *c.* 1600

Wh.5888

Objects like this tiny, delicately engraved sundial are messengers from the past: they would like to tell us about the mines and forests from which their materials came, about the craftsmen and women who laboured to make them and the tools they used, about their owners, the hands that held them, the journeys they have been on, the knocks they have taken and careful acts of restoration and repair they have known. But of course they are silent until the right interpreter comes along to coax them into speaking.

This instrument was purchased because it so obviously has plenty to tell. On one face there is a 'Rojas projection': a lattice of celestial co-ordinates and hour lines that can be used as a 'universal' sundial, for telling the time at any latitude. This ingenuity comes at a price, however: the sundial is quite hard to use and requires a little bit of skill and expertise. On the reverse of the instrument, therefore, there is a very compact inscription in Latin – an instruction manual in miniature.

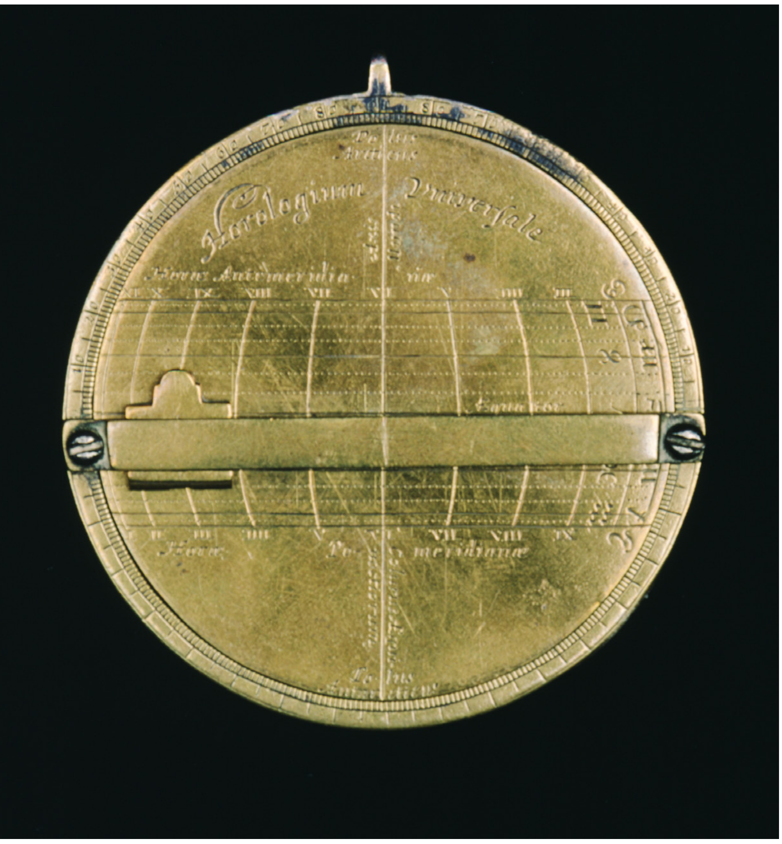
In 2003 the 'Latin Therapy Group' in HPS decided to tackle this sundial, as part of a project to translate a series of early-modern instrument 'texts'. This one proved tricky because the inscription is so contracted. We expected comprehensive instructions, but instead various operations are expected to be known. In the end we published a full translation,* but only with help from Anthony Turner and a substantial modern treatise on the Rojas projection and instruments that make use of it.† It turned out that a crucial part of the instrument was missing – once we had made a cardboard model with a replica of this component, everything slotted into place, and we reached the level of technical competence of an average 16th-century

* Catherine Eagleton, Jennifer Downes, Katherine Harloe, Boris Jardine, Nick Jardine, Adam Mosley, *Instruments of Translation* (Cambridge: HPS Latin Therapy Group/ Whipple Museum, 2003).
† Francis Maddison, *Hugo Helt and the Rojas Projection* (Coimbra: Junta de Investigaçãoes do Ultramar, 1966).

sundial owner. (It has sometimes been rather cruelly suggested that the entire Latin Therapy Group has only ever reached the level of Latin of an average 16th-century schoolchild!)

In spite of this hesitating success, many of the sundial's secrets remain unspoken: metallurgical analysis reveals brass with very low impurities; the script and quality of workmanship suggest an origin in the Low Countries, probably *c.* 1600. Might the text itself have an origin in a printed or manuscript source? Could the engraving be identified more closely, to a particular workshop or maker? As the many multiply-studied objects in this volume attest, there are as many possible interpretations as there are interpreters.

Boris Jardine



10-inch terrestrial globe, containing orrery, by Benjamín Tena, Spanish, late 19th century

Wh.5892

The Whipple Museum catalogue lists it as a '10-inch terrestrial globe, containing orrery', but a glance at Wh.5892 reveals it to be somewhat less – and yet much more – than that. The three roughly soldered, freely moving disc-planets seem unworthy of comparison with the monumental 18th-century Grand Orrery that stands proudly in the Museum's main gallery. Yet the carved wooden gears that carry the Earth around a circle decorated with motifs of the seasons, as one turns the brass handle set atop a bulbous Sun, betray the care that went into its cottage-industry production. This assemblage instantly transports the viewer back to the Spanish hilltop town where it was made around 1900.

It was purchased for the Museum in 2002, but had not been formally studied until Liba Taub 'matchmade' (as was her wont) me with it for one of my MPhil Essays in 2011–12.[*] At Liba's suggestion, the Cambridge University Communications team wrote an article and made a short film about it, and it was reported by various newspapers as an early example of interactive education.[†] One of those news reports was spotted by the descendants of the maker, still living in the same Spanish town, who were able to fill several gaps in the story of the globe's production, as well as donating a set of uncut interior gores to the Museum.

The globe connects Spanish educational reform with French popular science and central-European mass production, in an era when public science and trade were expanding rapidly. Its maker, Benjamín Tena (1856–1902), was an agricultural surveyor in Villafranca del Cid, in the hills in the far northwest of the Community of Valencia. The established Valencian firm J. Ortega undertook the lithography, but the design was evidently Tena's own.

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* Sebastian Falk, 'A Spanish Globe: Origins and Interpretation', *Globe Studies* 59/60 (2014), pp. 142–59.

† 'The World Inside a Spanish Globe', University of Cambridge research blog, 28 Dec. 2012: https://www.cam.ac.uk/research/features/the-world-inside-a-spanish-globe.

The globe's cartography is strongly reminiscent of models produced in the late 19th century by manufacturers such as Felkl (Prague) and Schotte (Berlin). Both made globes in many languages – including Spanish – for export, and one of Schotte's models had the same diameter (25cm) as Wh.5892. However, certain elements of the cartography, such as the Madrid meridian and labelling of Colombia by the archaic name of 'Nueva Granada', are atypical. It seems, therefore, that the cartography was an adaptation of central European models.

The interior is filled with didactic information about astronomy, geology and natural history. A note specifies that 'almost all the opinions and calculations given here come from [Camille] Flammarion [1842–1925]' – but in fact the main source is another work of popular science from the same era: *La Terre Avant le Déluge* [*The World Before the Deluge*], by French author Louis Figuier (1819–94). Tena's copy of this work survives in his family's collection, with several passages and images that he copied directly into the globe marked in the margins.

Such an educational toy is typical of pedagogical reforms in late 19th-century Spain, represented above all by the Free Institute of Education led by Francisco Giner de los Ríos. In a speech in 1880, he described his vision: 'the teacher surrounded by a small circle of active pupils who think, talk, discuss, move, who are alive, and whose dreams are ennobled by collaboration with the teacher [...] Now they feel they are something in the world, and it is no sin to be an individual [...] And then the classroom becomes a workshop and the teacher a guide; the pupils, a family'.‡ It is easy to imagine our globe in such a classroom.

Seb Falk

‡ Francisco Giner de los Ríos, *Ensayos* (Madrid: Alianza, 1969), p. 107 (my translation).

Two chassis from the EDSAC 2 computer, English, 1958–65

Wh.5901

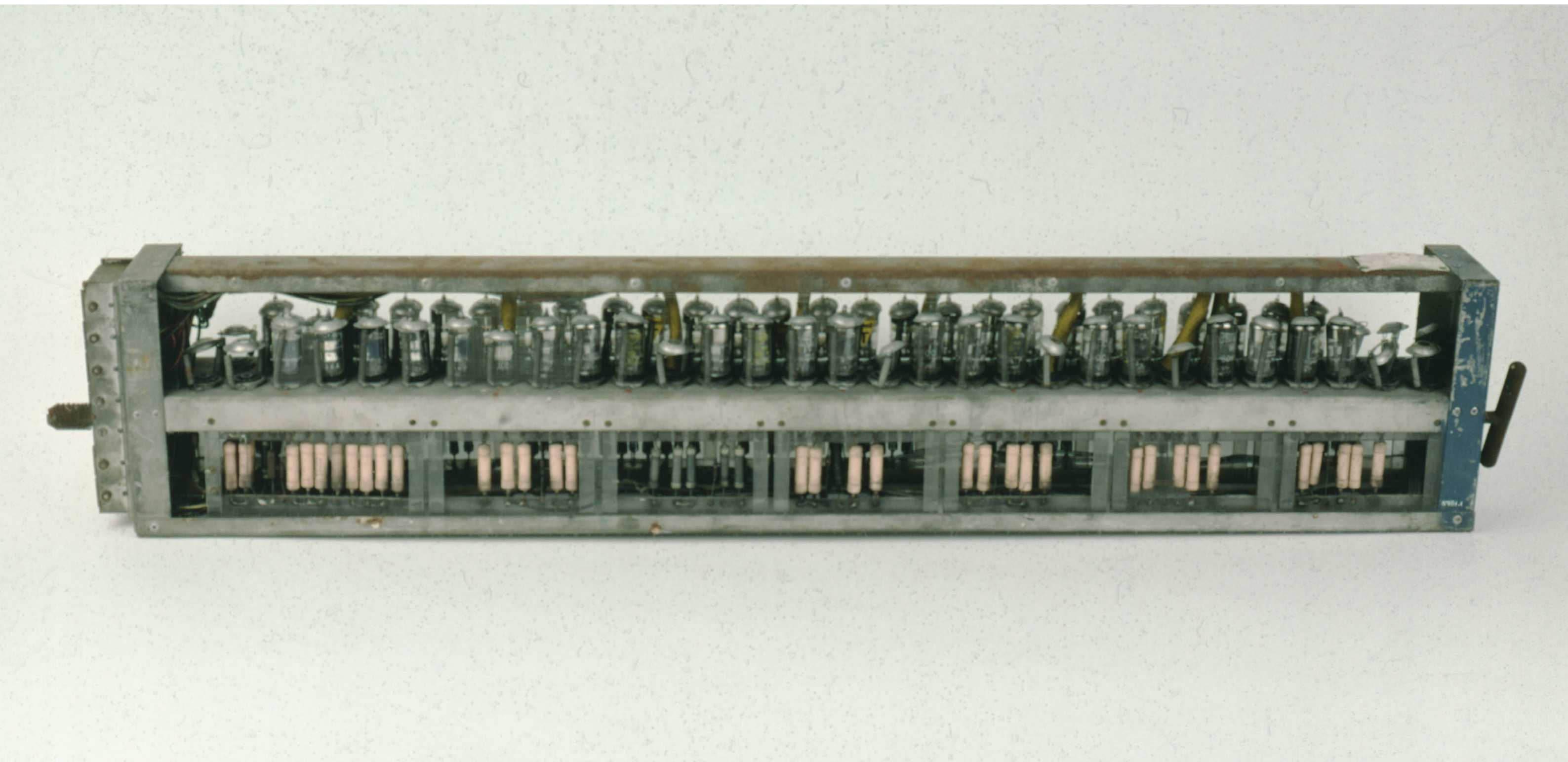
Some of the Whipple's treasures were purchased at auction, in tense bidding wars with fatcat collectors (e.g. Wh.6145, pp. 82–83). Some were donated by scientists nearing retirement, wanting their treasured inventions to find a good home (e.g. Wh.6743, pp. 152–54). Some were carefully chaperoned through their afterlives by the curators of private museums (e.g. Wh.6547, pp. 118–19). And one was found in the bottom of a cupboard, inhabited by mice and even smaller denizens, in an obscure room at Denny Abbey Farmland Museum a few miles north of Cambridge.

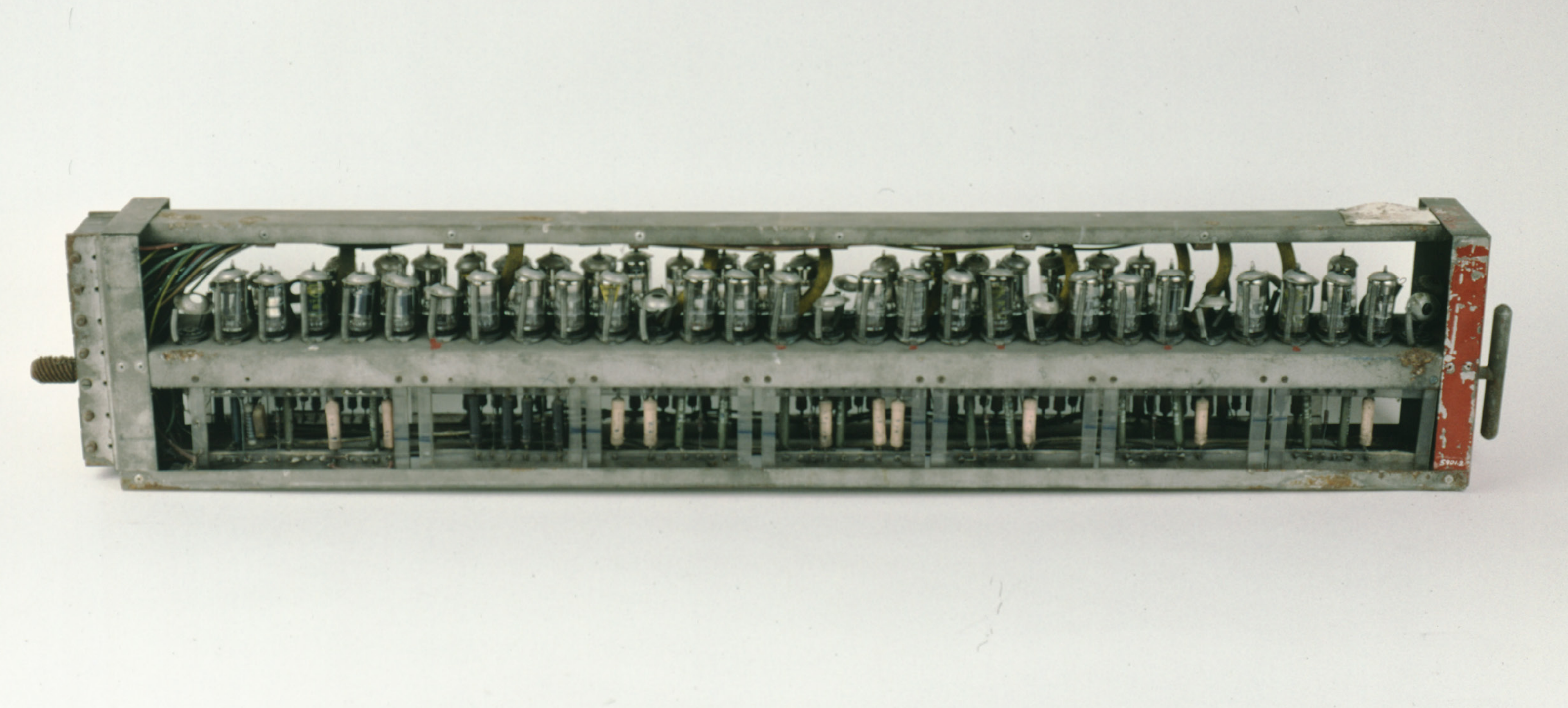
This was the unlikely resting place of two 'chassis' from the pioneering electronic digital computer EDSAC 2 (the second version of Cambridge's Electronic Delay Storage Automatic Calculator). The first EDSAC, begun in 1947, was one of the first electronic digital computers anywhere in the world, and was quickly put to use in important scientific work – especially genetics and crystallography.

EDSAC 2 was designed by the same team that had created EDSAC, and therefore drew on their experiences and featured many improvements. The core technology of banks of vacuum tubes made up the 'arithmetic logic unit' – these banks could be slid into position and changed, depending on the specific operation being carried out.

One of the greatest of all curatorial joys is the absolute lack of any relation between historical importance and the different *kinds* of acquisition: especially in Cambridge, something found in a skip or an almost-forgotton cupboard may end up being as important as an highly-valued treasure.

Boris Jardine





Navicula, ship-shaped dial, early 19th century

Wh. 5902

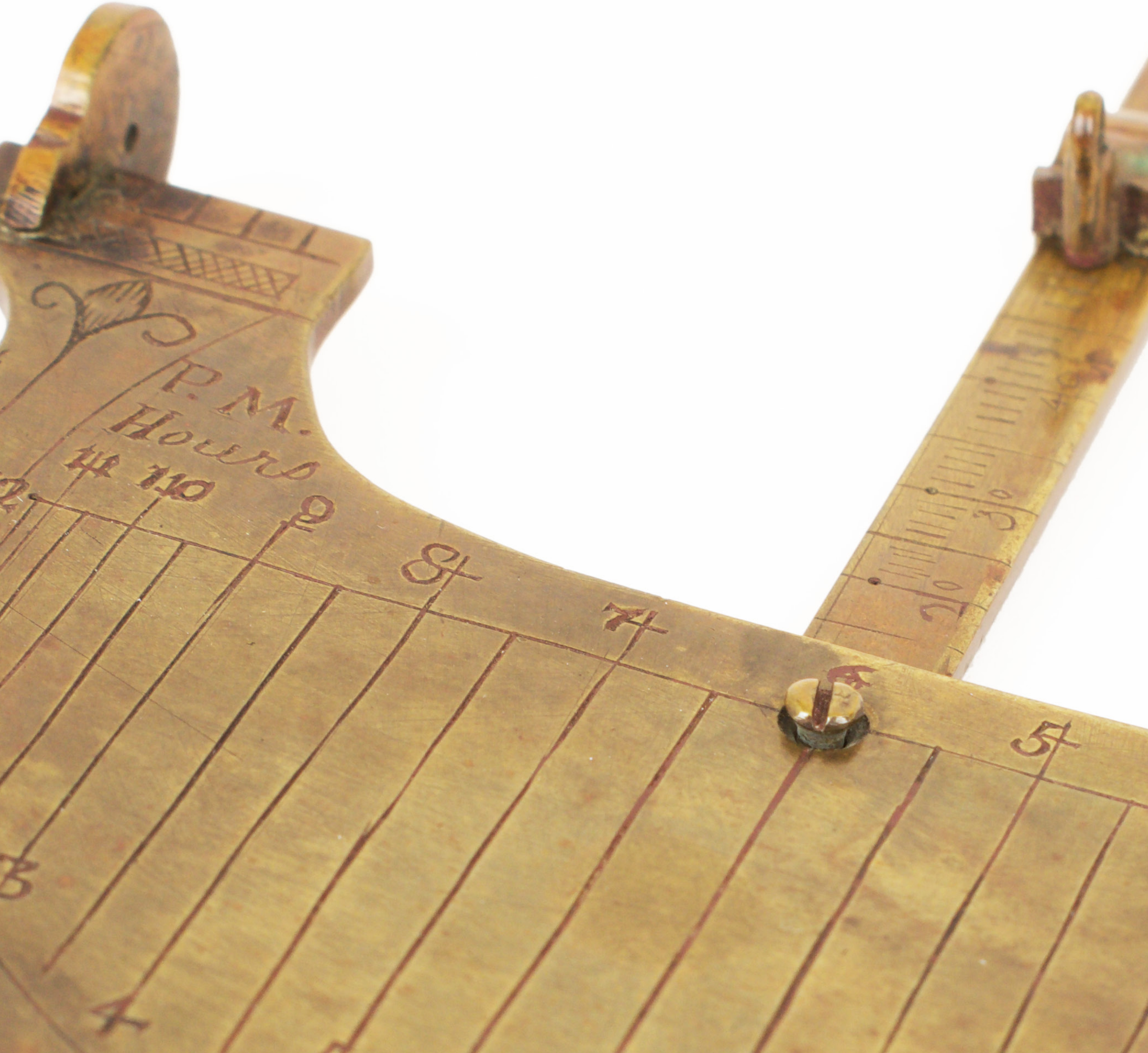
This type of ship-shaped sundial had its origins in medieval England, and a number of instruments and manuscripts survive from that period. Through the 16th and 17th centuries there are occasional references to the navicula, and manuscript annotations show that the medieval texts on the instrument were still being read. The instrument appeared in some printed books, and the Whipple Museum collection also includes a navicula made in 1620 (Wh.0731), that was copied from diagrams printed in a 16th-century book.

By the late 18th century and early 19th century, naviculae were of interest to antiquarians and collectors, and the style of the engraving on this instrument as well as places listed on the back indicate that this is probably when it was made. This navicula has some decorative details in common with surviving medieval instruments, including crosses at the top of the hour lines, but unlike them it has no astronomical or geometrical scales on the back. So, presuming the W. H. who has signed this instrument is its maker, they were probably working from a text rather than from a surviving medieval instrument when they made it.

Looking closely at the front of the dial may reveal a more specific context and set of textual connections. On the front of this instrument, there should be a second scale along the midday line (on the right-hand side), used for setting the position of a small bead on the plumb-bob. Without that scale, the instrument would not have worked. This small but important detail links this navicula more specifically to a number of 15th- and 16th-century manuscripts about a ship-shaped dial, most copied in German-speaking parts of Europe, which also lack the section describing how to construct the scale along the midday line.

Many scholars – W. H. in the past, and students working with Whipple Museum collections today – construct models and instruments from written instructions or from diagrams in order to understand them in more detail. As W. H. perhaps found out when they made this navicula, following the instructions in a text can be a way to determine what it does – and doesn't – set out accurately and clearly. So, in the Whipple Museum collection this instrument shows how later scholars have studied medieval astronomical instruments, and it also complements the 1620 navicula by speaking to the connections and relationships between instruments and books.

Catherine Eagleton



Universal equinoctial ring dial with Devanagari script, Indian, late 19th century

Wh.5907

At first glance, this is simply one of many universal equinoctial ring dials – a popular type of portable sundial originally developed in early-modern Europe, and a common sight in European and North American museum collections. Yet it is ornately inscribed in the Devanagari script of Sanskrit and Hindi, with a design featuring elements of both European and South Asian systems of astral knowledge. On further investigation, the plot thickens: it turns out to belong to a loose collection of eight similar dials, scattered around global museum collections, all apparently made in or around late 19th-century Rajasthan.* Coming into a world increasingly reliant on clocks and watches for telling time, why were these examples made; for what purposes could they have been used?

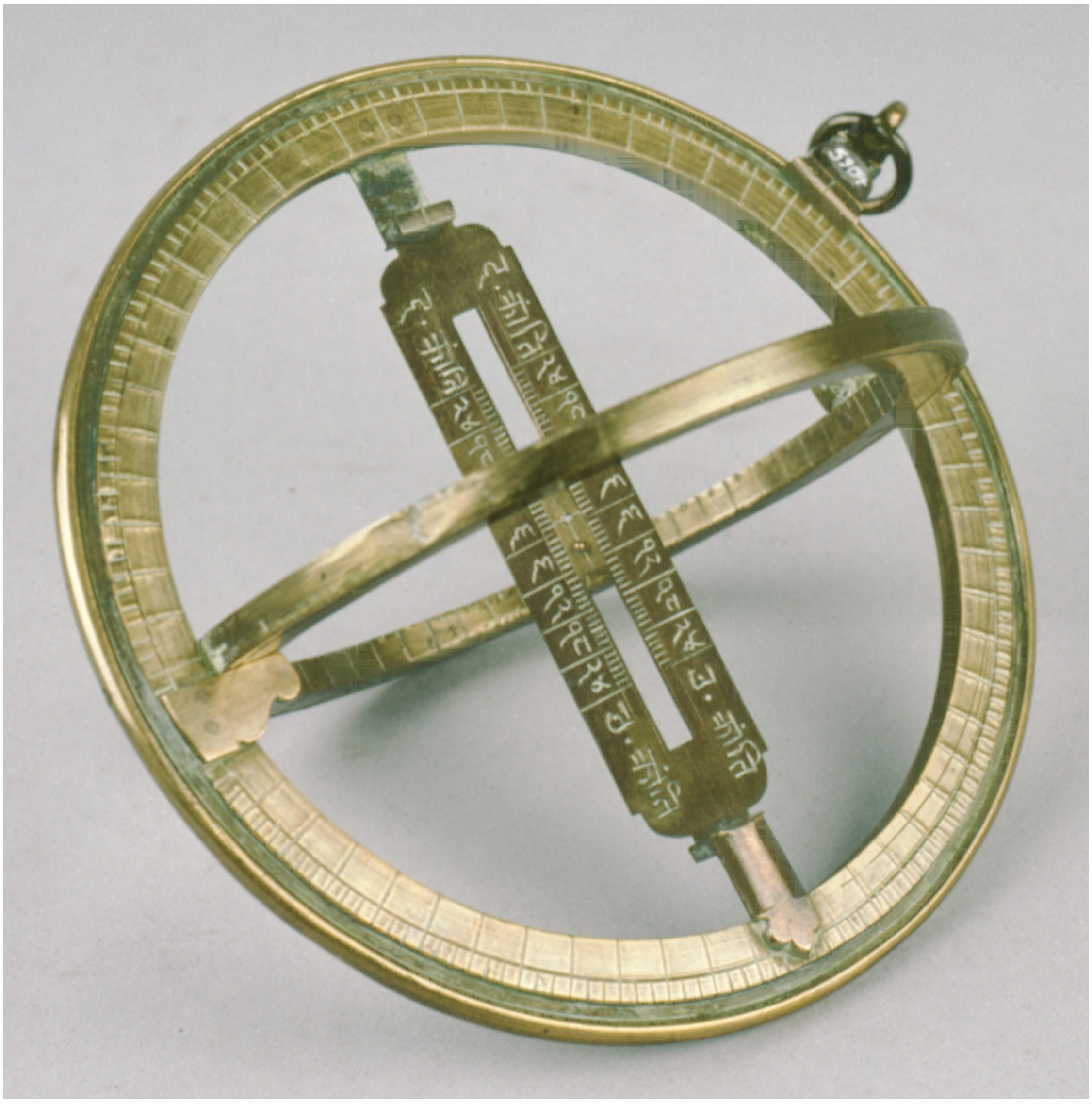
With almost no existing documentary evidence about any of the dials, it was at first hard to proceed. However, by focussing on the question of use, rather than provenance, I began to realise how their ambiguous origins and identity can contribute to the existing historiography of scientific instrumentation in the context of studies of scientific colonialism in late 19th-century India. They appear to have connections to Jaipur, a centre of Hindu astral tradition with a famous stone observatory, despite elements of the design's construction suggesting connections to European instrument-making tradition too. And while they could have served practical purposes – as teaching devices, for example, or symbols of status – their main function was likely as ornaments that embodied colonisers' vision of Indian tradition.

Thus these dials belie simple classification as either European or indigenous Indian instruments, or as 'old' or 'new' devices. Instead, judgements of the authenticity of such objects should be dependent on the contexts

* See Sreeramula Rajeswara Sarma, *A Descriptive Catalogue of Indian Astronomical Instruments*, 2nd edn. (Dusseldorf: the author, 2019), pp. 4015–29.

of their use. The dials therefore challenge our notions of obsolescence, and highlight the ways in which scientific instruments can serve not only to make and calibrate forms of scientific knowledge, but also to construct traditions, histories, and historiographies too.

Francis Newman



Model of the human eye in the form of a camera obscura, late 19th century

Wh.5984

THIS MODEL OF THE HUMAN EYE demonstrated the mechanical operations of the eye using the principles of the camera obscura. At the back of the eye model, where the retina is located, sits a glass screen. A glass lens is placed in front of the eye opening, which focuses light as it passes into the eye and projects an image onto the screen located at the retina. The result is an upside-down image. In human vision, the brain 'corrects' the upside-down image, producing a picture of the world right-side up. Two additional lenses accompanied this eye model, which simulated the conditions of far- and short-sightedness. These lenses change the focal length so that the focus point falls either in front or behind the retina, producing a blurry image.

Allison Ksiazkiewicz

Laboratory stand with cast metal hairy feet, early 20th century

Wh.5987

Museum objects occasionally come from rubbish skips. This laboratory clamp stand was thrown into a skip outside a London school in 2003. Cast out as no longer useful, the stand was noticed by an eagle-eyed historian of chemistry, who recognised its historical value and brought it in to the Whipple Museum. I can think of twenty or so objects that have arrived in the Whipple's collection after first being thrown away as rubbish.

The stand was made around the first half of the 20th century, and its distinctive base resembles furry animal feet. Museum staff were intrigued by its appearance and nicknamed the object 'Friedrich' – for reasons I now forget. Friedrich has featured on at least one staff birthday card during his time in the Museum, and was a star object in the 2017 exhibition *Why is This Here? Exploring the Curious and Controversial in the Whipple Museum's Collection*.

Ruth Horry

HP-35 electronic pocket calculator, by Hewlett Packard, Singapore, *c.* 1973

Wh.6015

'Don't settle for less,' read a 1972 advertisement for the HP-35, 'the world's first pocket calculator that challenges a computer,' with a $395 price tag. Consultants advised Hewlett-Packard that their target market of technical professionals would balk at the price, since they relied on slide rules that cost less than $5 and regarded electronic calculators with suspicion – glorified adding machines that only approximated scientific functions. In a nod to their concerns, the company marketed the HP-35 as an 'electronic slide rule' and invested in advertising that pitted it against an expert slide rule user to show that their machine was faster and at least more precise, if not more accurate. Moreover, its Reverse Polish Notation system, which post-fixed operations, was likened to a computer programming language. The gambit worked. More than 50,000 units were sold in its first year and the HP-35 inspired a whole line of scientific calculators.

My encounter with this device speaks to its place in the Whipple. Before shipping off from Chicago to Cambridge for an MPhil, I asked the late Alison Winter what an aspirant American historian of computing might look out for – apart from Simon Schaffer's table at the Eagle pub. She told me about a collection in the Whipple Museum that included a 'feminized' handheld calculator in the shape of a makeup clamshell. I was delighted to see the range of objects in the Hookham Collection and the ephemera that came with them. After reading Sophia Davis and Catherine Eagleton's brilliant article 'Touching Numbers', which used the collection to explore the relationship between numeracy and the haptic,* I thought that was that. Still, I kept mulling over future Prime Minister Boris Johnson's 1988 *Daily Telegraph* column that derided the Whipple for its acquisition of such obsolete gadgetry – what next, he asked, odd socks?†

* Sophia Davis and Catherine Eagleton, 'Touching Numbers', *Anthropological Theory* 10 (2010), pp. 192–97.
† Boris Johnson, 'Enter the Age of the Instant Antique', *Daily Telegraph*, 26 Oct. 1988.

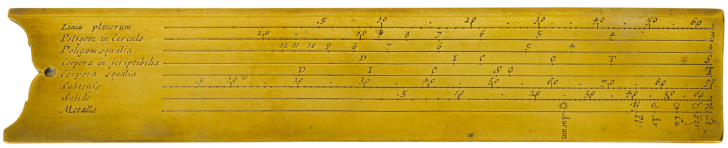
It all clicked when I learned that the HP-35 was effectively a pocket-sized version of the HP desktop calculator nestled between advertisements for beads, yarn, and buckskin in Stewart Brand's *Whole Earth Catalog*, a magazine that promoted 'access to tools' for communitarian living experiments regarded as a touchstone of the 1960s counterculture that influenced a generation of tech entrepreneurs. One cannot begin to understand the social history of computing without grasping the extent to which the high church of supercomputing and the messy vernacular of crappy consumer electronics have long been intertwined. HP expanded its range of scientific calculators to include card readers for stored programs, supported by a rich network of users, eerily resembling the mobile app marketplace of today. The HP-35 started it all. The proliferation of handheld calculators certainly reflected a crude consumerism, but also channeled anxieties about a diversifying workforce amid an economic downturn and ambivalence over the potential for 'personal' devices to erode the boundary between hobby and labor. These social tensions remain with us, long after most gadgets have been discarded into a transistorized trash heap. And to Boris, I am certain that many an able garment historian could unravel a rich social tapestry from the right pile of odd socks.

Michael McGovern

Three examples of the ‘reigle platte’, Low Countries, early 17th century; proportional compass, Low Countries, *c.* 1600; two transitional sectors, by Elias Allen, English, *c.* 1615

Wh.6016, Wh.6631, Wh.6713; Wh.6715; Wh.6643, Wh.6654

Throughout her time as Director of the Whipple Museum, Liba has shown herself adept at answering two apparently unrelated questions: which historical artefacts will provide the materials for the history of science? and who might thrive by working closely with these obscure and wonderful historical treasures? For some of the luckiest contributors to this volume Liba has answered both questions at once: as a neophyte Museum employee I was given the opportunity to identify and even bid at auction for new acquisitions to the Whipple's famous collections.

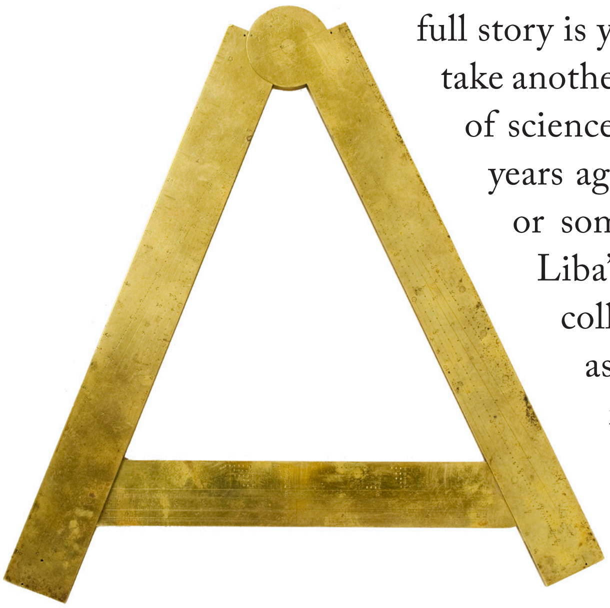


My co-editor James Hyslop was another young Whipple employee with a good eye for an interesting artefact, and it was James who spotted, in a Tesseract catalogue in 2004, an unusual calculating device called the ‘reigle platte’. This little brass rectangle is engraved with unequally divided scales with labels like: ‘*Poligoni in Circulo*’, ‘*Corpora æqualia*’, etc. The Coffeens, drawing on the fine scholarship of Ad Meskens, gave a useful outline of what this instrument is for: ‘Using compasses and a straightedge, one transferred measurements from the reigle platte to paper, and found extensive mathematical answers geometrically.’* For the two lines I mentioned, it is possible to make various calculations in what we would call ‘pure’ and ‘applied’ mathematics, having to do with polygons inscribed in circles, and the dimensions of Platonic solids.

* *Tesseract: Early Scientific Instruments, Catalogue Eighty Four* (Hastings-on-Hudson, ny: Tesseract, 2004), no.31. See Ad Meskens, ‘Michiel Coignet's Contribution to the Development of the Sector’, *Annals of Science* 54 (1997), pp. 143-60.

In the years since that first fateful acquisition, the Whipple has built on James' insight by purchasing two more 'reigle plattes' from Tesseract, as well as an early 'proportional compass' (right), and an important pair of sectors by the English craftsman Elias Allen (below). When Meskens was writing, no reigle plattes were known to survive; now the Whipple possesses three of the four that have come to light. The proportional compass is one of three known that are based on a 1597 text by Guidobaldo del Monte. The Allen sectors are 'transitional' because they predate the 1623 form of the sector that Allen was to go on to popularise.

Looking at these instruments as a group, a new picture starts to emerge, of an intellectual and practical world obsessed with geometry and arithmetic. The proportional compass came first: an ingenious device that allowed operations to be made directly on a drawing surface. Around 1595 a number of practitioners realised that the compass was more powerful than this: new scales could be inscribed that would allow operations to be made in the abstract – now arithmetic itself was an instrumental practice. Over the next fifty years or so the new 'sector' came to dominate navigation, surveying, architecture, sundialling – even the calculation of interest, taxes, wages…



This is a decisive moment in the history of computing. The full story is yet to be written. Will I take on the task, and take another step in the journey into the material history of science that Liba started me on more than twenty years ago? Or will it be a promising MPhil student, or someone looking for a PhD topic? Following Liba's lead, I am as happy to pass this on as to collaborate, as content following my own path as I am contributing, in my small way, to the interpretation of the Whipple's world-leading collections.

Boris Jardine

Objective lens, 11.6-inches, for the Northumberland telescope, by Robert-Aglaé Cauchoix, French, 1834

Wh.6076

In her 2003 contribution to a group of essays on universities' science collections, Liba Taub perceptively argued that since museums of history of science tend to show 'finely-made objects rather than crude prototypes', their displays might wrongly suggest that whereas modern scientific practice is often seen as 'fraught with dangerous and difficult choices', past science looks as though it was 'always elegant and refined'. Look at this elegant lens, made about two centuries ago from two kinds of glass. The two types have different amounts of lead and silica, so different capacities to disperse incoming light. Balancing these capacities was a refinement that helped avoid image distortion. The Cambridge University telescope that held the lens, completed in 1839, gathered starlight with this object glass and let astronomers minutely examine the resulting image with a smaller eyepiece. It was pricy kit. The whole telescope cost about £2,000 and a further £800 – about £60,000 in modern terms – was shelled out for the big object glass. It offered more light and sharper images, but was hard to make and manage: such glasses were prestigious prizes sought by rival patrons.

The lens was made by Cauchoix, an experienced instrument-maker at Quai Voltaire in central Paris. He got quality stock from an expert old Swiss glassmaker Pierre-Louis Guinand, who had clever ways of making huge optical blanks without specks or bubbles. In 1829 Cauchoix got £1,200 for what had been the largest object glass in the world, the precursor of this one, from the irascible and wealthy Kensington astronomer James South. But it was put in a London-made telescope South reckoned so ill-fashioned he destroyed the instrument and sold it as scrap. Cambridge had its own new observatory run by the young mathematician George Airy, introduced to practical astronomy by South and his closest ally John Herschel. During summer 1833 Herschel acted as astronomical agent for the Duke of Northumberland, a rich nobleman who bored his peers and was loathed by his tenants. A Cambridge graduate, the Duke was tapped for cash for the University's observatory. Herschel quizzed Airy about a Cambridge telescope and asked South to sell one of his valuable Cauchoix

lenses. Then Cauchoix himself contacted Herschel offering him this lens of almost one foot in diameter, the same as that sold to South. Herschel's endorsement offered great advertising. Herschel countered that Cambridge would be a better home for the glass and sent Airy to meet the Duke at Buxton spa to agree the scheme.

It took eighteen months for the prestigious glass to leave Paris. Cauchoix reported it had been broken and one of its components reground. Airy exhaustively planned a new telescope, named for the Duke, to hold it. In late 1834, he sent the lens for testing to Upper Street Islington, where the optician William Tulley decided it wasn't as good as advertised. Airy reassured the Duke the vast telescope with its Cauchoix lens would cope with tracking comets and planets. After Airy became Astronomer Royal at Greenwich in 1835, he and his more modest Cambridge successor, James Challis, tried to tame the telescope and its object glass, by changing its aperture and tilting it in the tube, making it fit for examining eclipses and double stars, moons and comets.

During summer 1846, when some European astronomers predicted there might be an unseen planet beyond Uranus, Airy told Challis it could only be found with the Northumberland Telescope. Airy was wrong: though the Cambridge team did see it through their Cauchoix lens in August 1846 they didn't identify it as a planet. And the next month, the discovery of Neptune was announced from Berlin. Herschel grumbled that 'Neptune ought to have been born an Englishman and a Cambridge man every inch of him'. The Neptune affair affected the reputation of Airy, Challis and their Northumberland instrument. The Whipple Museum also holds various components of the original telescope, including eyepieces and filters. The Cauchoix lens itself stayed in service until 1937. Its experiences reveal how fraught and difficult could sometimes be the careers of finely-made objects of past science.

Simon Schaffer

‘Celestial Indicator’, planetarium within a Copernican armillary sphere, by Henry L. Bryant, USA, *c.* 1872

Wh.5997

Henry Bryant patented the design for his ‘Celestial Indicator’ in 1872. He intended it as an ‘Improvement in Armillary Spheres’ – models of the solar system that have been made since Greek antiquity. His design places a planetarium within a Copernican armillary sphere. ‘My invention’, Bryant claimed, ‘is an instrument for use in schools, colleges, and the like, for illustrating and explaining various celestial phenomena, such as are commonly the subject of study and investigation in pursuing the study of astronomy.’

The Editors

Royal Air Force uniform buttons, one concealing a compass, by J. R. Gaunt & Son, English, *c.* 1940

Wh.6080

Both these World War Two-era buttons look the same, but one of them unscrews to reveal a tiny compass. This design is credited to Clayton Hutton, an MI9 intelligence officer who specialised in the creation of escape and evasion aids for allied servicemen.

The Editors

Hydrogen-oxygen fuel cell electrode, by Clevite Corp. for United Aircraft, USA, 1965

Wh.6081

An unassuming 29cm diameter grooved metal disc, surrounded by a few pipes, might go unnoticed if not for its plaque: 'Project Apollo — Fuel Cell Electrode'. After graduating in 1925 with a third-class degree from Trinity College, Cambridge, Francis 'Tom' Bacon never expected to develop power source that helped humankind set foot on the Moon.

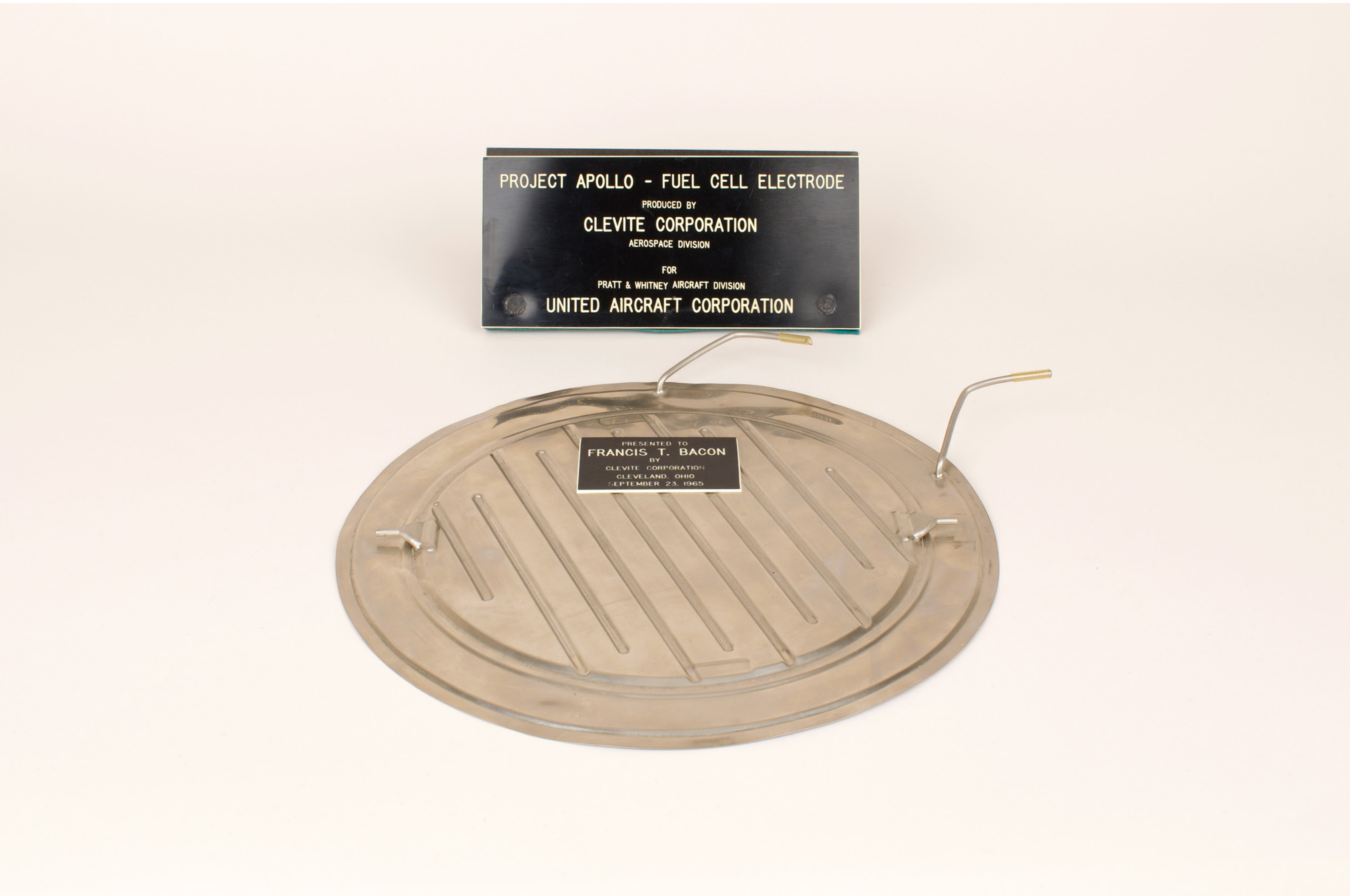
While working as an engineering apprentice in the 1930s, Bacon became interested in a 19th-century curiosity: fuel cells. With an anode, cathode, and alkaline electrolyte, hydrogen and oxygen could be continuously converted into electricity and water. Developing this technology into a form practical for everyday use became Bacon's goal. As a freelancer peddling potential applications rather than a functioning cell, Bacon's work was inconsistently funded. Following a stint at Kings College London, from 1946 to 1956 Bacon worked around the New Museums Site: in Colloid Science (between the Cavendish and the Laboratory of Physical Chemistry), in the department of Metallurgy on Pembroke Street, and finally in the temporary war-time huts on Tennis Court Road that housed the Department of Chemical Engineering.

Here, Bacon's team were shown a porous nickel sheet, origins obscured by the Official Secrets Acts, which they used to develop a biporous electrode structure: large pores on the gas side and smaller ones on the electrolyte side. This created a more stable system at the high temperatures and pressures needed for the reaction to take place efficiently. When funding was not renewed in 1956, Bacon had an anxious six months before the National Research Development Corporation (NRDC) took on the project. Working out of Hanger Six at Cambridge Airport with Marshall of Cambridge, in 1959 Bacon finally demonstrated a functional 5 kW cell.

As part of the deal, patent rights were transferred to the NRDC, who looked to make a profit. Across the Atlantic, in 1961 President Kennedy proposed the 'Apollo Moonshot': landing a man on the Moon and bringing him back to Earth. As part of this project, United Aircraft became interested in Bacon's cell. It had a theoretically impressive efficiency, its by-product, water, could humidify the capsule's atmosphere and provide drinking water, and hydrogen and oxygen were already being used as fuel and for life support. They took out a licence on the cell, and used it to win a $100 million bid to build Apollo's electrical power source.

With a near unlimited budget and thousand-strong workforce, the cell was perfected for extra-terrestrial use. Three cells, each comprised of thirty-one stacked electrodes, were placed in Apollo XI, and took Neil Armstrong and Buzz Aldrin to the Moon and back. Whilst Bacon dreamed of a world with cars and rail powered by his fuel cells, it has become central to the last four decades of human spaceflight. Bacon had cracked the problem of turning fuel cells into a usable technology, but its manifestation was far more extraordinary than he imagined. This prototype, given to Bacon to commemorate his contribution to the project, captures a uniquely Cambridge contribution to space science.

Katy Duncan

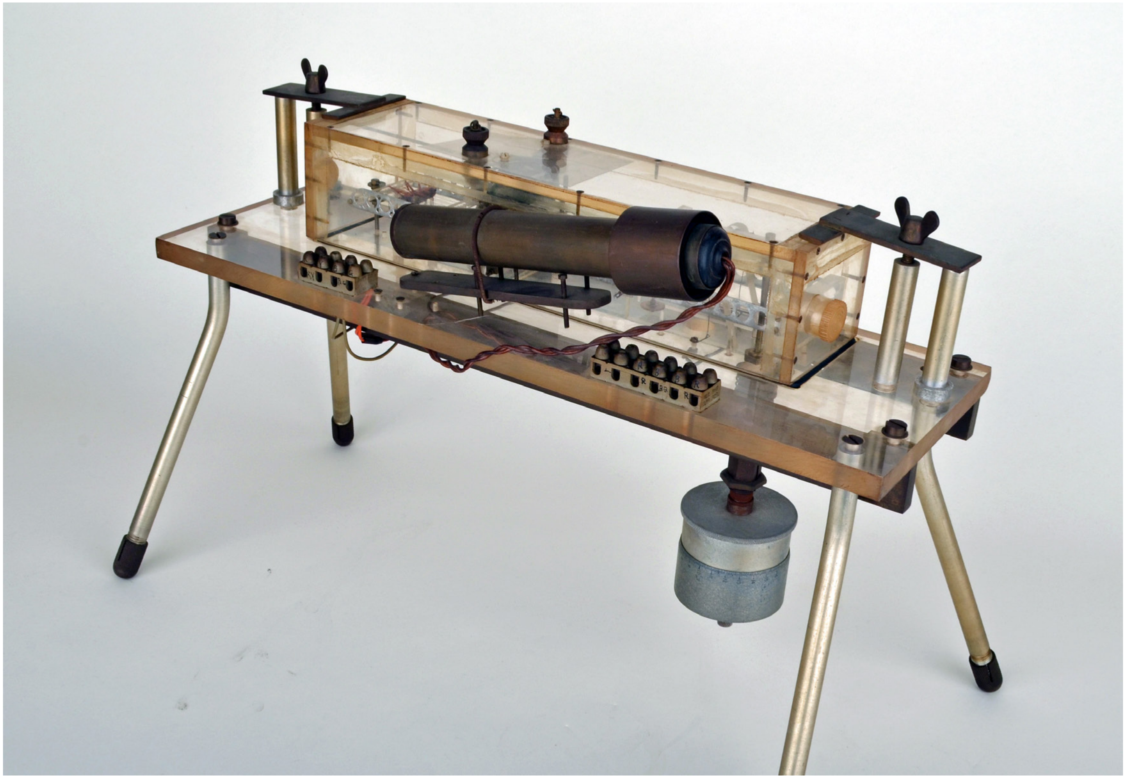


Beam balance, by James W. L. Beament, English, 1950s

Wh.6088

THIS BEAM BALANCE WAS USED in physiological experiments to measure the effect of temperature on the waterproofing mechanism of cockroaches. Cockroaches are waterproofed by grease excreted from the cuticle; Cambridge insect physiologist James Beament researched this effect in order to help develop more effective pesticides. The instrument is handmade by Beament and still contains a dead cockroach.

The Editors



Silk flower models, by Ceschwister Kalazdy and Kálazdy Növérek, Hungarian, late 19th Century

Wh.6099

Four didactic models used to teach economic botany: *coffea arabica* (Arabic coffee); *gossypium herbaceum* (Levant cotton); *vitis vinifera* (common grape vine); *papaver orientale* (oriental poppy). These silk models, labelled in German and Latin, provided an advantage over dried specimens, which were extremely delicate and suffered colour fading over time.

The Editors


Papaver orientale L.
Schlafmohn.

‘Sputnik’ globe toy, by Michael Seidel, West German, *c.* 1960

Wh.6089

In the Whipple Museum’s collection, there are several ‘Space Toys’. One might question why these are held in a University Museum whose main focus is on scientific instruments.

This ‘Sputnik’ globe is made from tin and shows various boat and aeroplane routes around the earth. It stands on a hemispherical base which depicts northern hemisphere constellations and has a clockwork mechanism that rotates two satellites. One satellite is a plastic spaceship containing an astronaut and the other is of the ‘Sputnik 1’ satellite. It was manufactured by West German toy company Michael Seidel.

Sputnik 1 was the first artificial Earth satellite and was launched by the USSR in 1957. The success of the satellite’s launch and subsequent orbits of the Earth triggered the Space Race. It was the beginning of a new era of political, military, technological, and scientific developments.

Public reaction to the ‘Sputnik crisis’ led to increased US spending on scientific research and education. The launch of Sputnik contributed directly to a new emphasis on science and technology in American schools and it inspired a generation of engineers and scientists with some later becoming involved with the Apollo and wider-astronaut programmes.

Coverage of the Space Race in cinema newsreels, on the radio and via the new mass medium of television made space travel a popular topic at school, and a key theme for toys and games in the shops, something which numerous toy companies capitalised on. Outer space has always had a powerful influence on children’s imaginations. But it was with the ’60s-era race to the Moon between the US and the USSR that such toys really took off.

During the Cold War, a huge number of space toys were produced. They included toy flying saucers, rocket launchers, ray guns and robots as well as globes such as the Whipple’s. The 1950s and 1960s were a golden age for such toys and helped countries such as Japan and Western Germany revive their damaged post-War economies.

As time went on, space agencies such as NASA released information to make the toys more accurate. This resulted in toys which provided education through play, and this is just one reason why globes such as the 'Sputnik' globe deserve a place in a pedagogical collection such as that of the Whipple.

Claire Wallace

13-inch lunar globe, by Räth, East German, *c.* 1961

Wh.6098

13.5-inch lunar globe, by Lipsky, Russian, 1967

Wh.6683

The forty-year global conflict known as the Cold War had many fronts. Some of them, like proxy wars in Asia and Africa, were hot; others, like the Berlin Wall or the northern North Sea, were indeed cold; but colder still were the battle lines drawn up in space. Famously, the Soviet Union sent shockwaves across the West when the first artificial satellite, Sputnik, entered orbit in 1957. The United States responded by sending humans to the Moon twelve years later. The history of this 'Space Race', a cultural competition as much as a scientific endeavour, can be found not only on film and in archives but also in museums. Among the Whipple Museum's collections from this era are Moon globes, simple spherical lunar maps that speak volumes about the importance of science in East-West competition (and vice versa). Most in the collection are American, showing NASA landing sites, but two of them are from the other side of the Iron Curtain, dating from the period when the Soviets were winning the Space Race.

Accession Wh.6098 is by East German globe-maker Paul Räth, showing areas that Russian probes imaged in the years following Sputnik. It includes details from the dozen or so photographs sent in 1959 by the Soviet *Lunik 3* probe, the first human-made object to orbit the Moon, which images had been published in Moscow in 1960 in the first atlas of the far side of the Moon. It turned out to be surprisingly different from the near side that astronomers had been studying for so long. Accession Wh.6098 is a lunar coup.

Even so, Räth's globe has uncharted areas: when *Lunik 3* circumnavigated the Moon, one third of the far side was in darkness. By 1967, however, as accession Wh.6683 shows, Soviet probes such as *Zond 3* had given Russian astronomers more comprehensive details of the lunar surface. Like the Räth globe, this one, by astrophysicist Yuri Lipsky, shows the prizes for victory in the Space Race – naming right to lunar regions. The International Astronomical Union approved *Mare Moscoviense*, for example, in 1961. The Cold War is inscribed on the Moon.

Artefacts like these unassuming globes thereby tell us about the relationship between science and geopolitics. They show the huge investments in astronomy made during the Cold War. They show how an 'imaginary war' (in the Global North at least) can manifest in material culture. And they evidence the strength and the depth of the Whipple collection, and the many stories we can tell with its objects.

Samuel J. M. M. Alberti

Ink drawing of a surveyor with manuscript annotations, French [attributed], 16th century

Wh.6103

This is a remarkable survival, and a rare depiction of an early surveyor with his tools. According to Richeson, the surveying chain per se was not in use until the 17th century.* So the curious object in the surveyor's left hand is surely his spool(s) of cord for line-measurement. Angle measurement was not part of normal surveying in the 16th century, and neither the rod nor the foot had been standardized. We cannot ascertain the true length of the illustrated rod, despite the rather precise specification that it is '1-½ p.', i.e. 1.5 perche. This French 'pole' measure varied greatly by local region; it was typically about 5 meters long, so the 'perche du Roi' was 18 'pied du Roi' or approximately 5.8 meters.

Executed in brown ink on laid paper backed with vellum, this charming depiction shows the well-dressed hirsute surveyor holding his rod and his cords or lines. Alongside is a series of eight geometrical figures, typical 16th-century flourishes, the signature 'Deneudilhac' (?) twice, two poems initialled in monogram at the end, and a motto.

Illustrations of early surveyors are rare. Some appear as quite tiny figures in illustrations of instrument use in early texts, and some are found on title pages, although in both cases these are likely to depict putti. Our master of his craft is well dressed as a bourgeois European of the second half of the 16th century.

Yola and David Coffeen

* A. W. Richeson, *English Land Measuring to 1800: Instruments and Practices* (Cambridge: MIT Press, 1966), p. 34.


Par mon Arismetique
Dieu m'a donné credit
D'Avoir de la practique
Si l'Arpentement dit
SPES
MEA
DEVS
A Dieu la lande qui n'est point trop en lande
Mais bien plus tost en terme bien fertil
L'arpenteur Queert & bien te Recommende
D'entretenir ce labeur bien subtil
P B

Slate epact calendar, signed ‘B|T’, mis-attributed to Tycho Brahe, Italian, mid-17th century

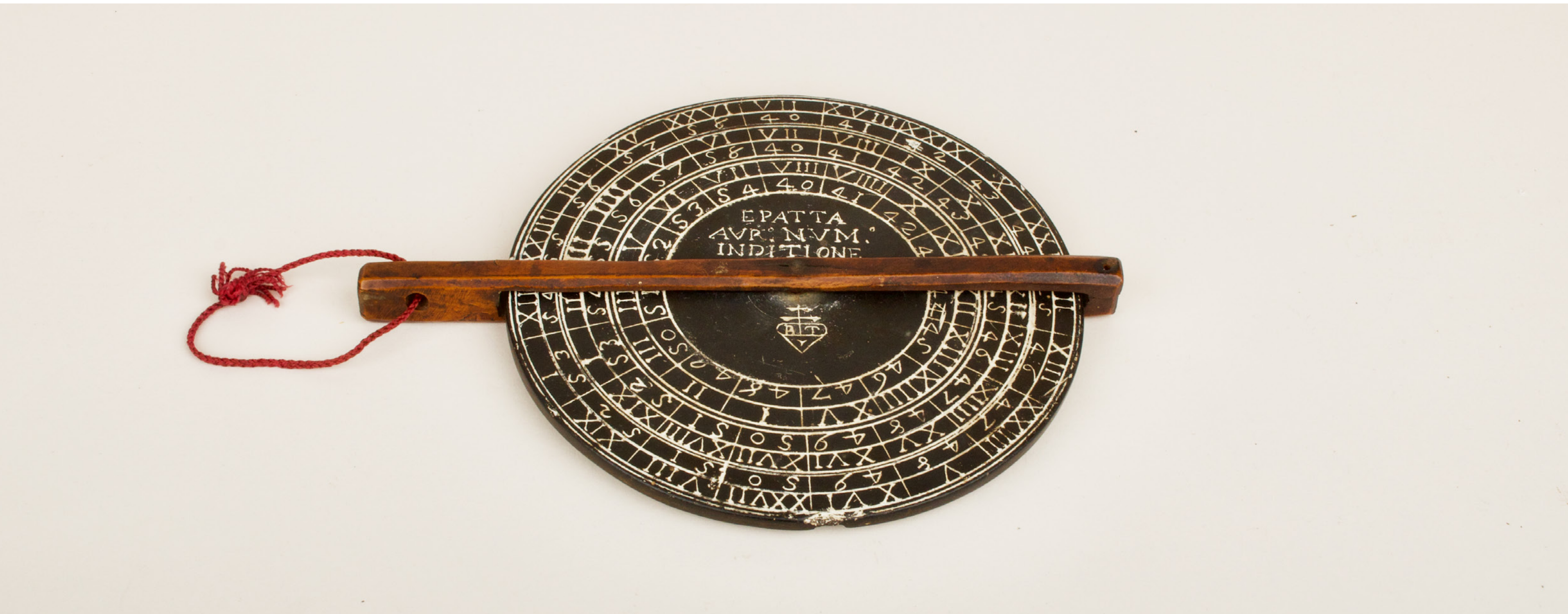
Wh.6134

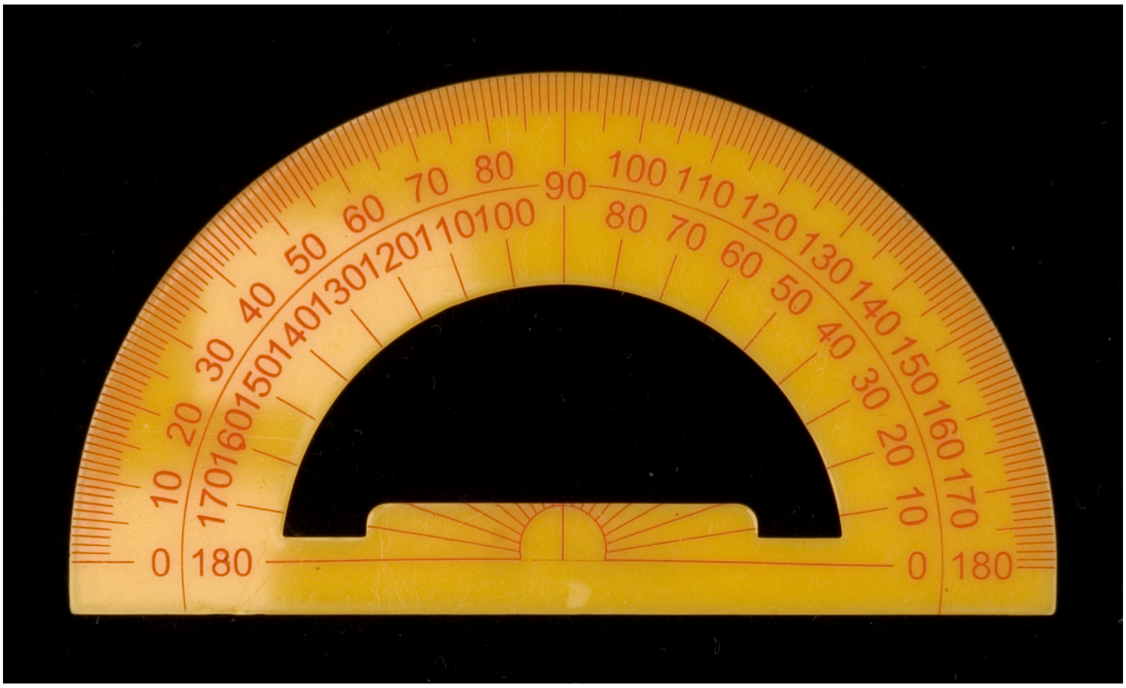
Compared to the rest of the art market, the history of collecting scientific instruments is a relatively short one, and in the last century questions of authenticity have tended to be settled by improved scholarship rather than amateur connoisseurship. Like the rest of the art market, the provenance of an object can greatly increase both its desirability and an auctioneer’s estimate. When it appeared at auction in 2007, no doubt the driving factor behind this object’s valuation was its provenance: ‘The Nachet Collection, No. 135 but described in the catalogue as an astrological instrument.’

The catalogue description omitted mention, however, of an attached label with an awkward attribution for a mid-17th century instrument: ‘Cercle signe B.T / Attribué par la / Tradition orale à / Brahe Tycho / (1596–1601) / NACHET N 135.’ The monogram ‘B|T’ sits in an engraved pattern not too dissimilar to a woodcut printer’s device of the early 16th century. So perhaps the overoptimistic attribution to Tycho Brahe was not quite as lazy a piece of scholarship back in 1929 as it would be today.

Whipple staff now suspect that this object may not even date from the 17th century, which would be the perfect final twist in the tale of an object whose description has changed every time it changed hands on the market.

James Hyslop





Faulty protractors, 1990s

Wh.6139

WHY COLLECT THINGS THAT DON'T WORK? These protractors are useless, and seemingly worthless, made from cheap opaque plastic that makes it impossible to use them properly. Yet they're a favourite amongst the Whipple Museum's staff, because they record a curious and fascinating piece of mathematical history. When school teacher Peter Bailey noticed that many of his pupils were mismeasuring angles, he realized that shops were selling faulty instruments. Peter began waging a campaign of letter writing to retailers, importers, and even the manufacturers themselves, demanding that they desist from supplying shoddy products. The Whipple's collection now includes these letters, their recipients' often contrite responses, and Peter's own account of how he successfully 'rid the world of useless protractors.'

Joshua Nall

Set of papier-mâché models of horses' teeth, by Auzoux, French, 1890

Wh.6135

I first encountered these papier-mâché horses' teeth models as a new MPhil student in HPS, making the switch from a rather unsuccessful spell on the Veterinary Science course. Eleanor Robson, then MPhil manager, suggested they might make a suitable topic for my first essay, supervised by Liba. The models are a delight. Beautifully crafted and wonderfully creepy, they sit in a specially designed green painted storage and display box. Such is their charisma that, for a number of years, they have featured as the profile picture for the Whipple Museum's Twitter account.

The models were made by Louis Auzoux, a medical school graduate who established a factory creating papier-mâché 'Anatomie Clastique' models in France in the first quarter of the 19th century. These models featured removable parts that could be taken out piece by piece, mimicking a real dissection, and were intended to solve the problem of a lack of fresh cadavers available for medical students.

The horses' teeth models form a set of 31 pairs (two of which are missing) of articulating jaws, showing how horses' teeth present at different ages and identifying some common abnormalities. Since horses' teeth change with age in a reliable manner, it is possible to tell a horse's age more or less accurately by looking at its teeth. These models could thus help to teach someone the art of ageing a horse, as well as indicating some common dental problems. They would have proved useful for training veterinarians, as well as cavalrymen, for whom an understanding of equine anatomy was very important.

The Whipple set appears to have belonged to a secondary school in Bar-le-Duc, and so may have been used to teach school students about equine dentition. Given the central importance of horses to the French economy during the 19th century, it is perhaps unsurprising that learning how to age horses and assess their health was considered a valued skill of school students.

Rebecca Brown

Brass Gunter quadrant, by Thomas Poole, English, 1689

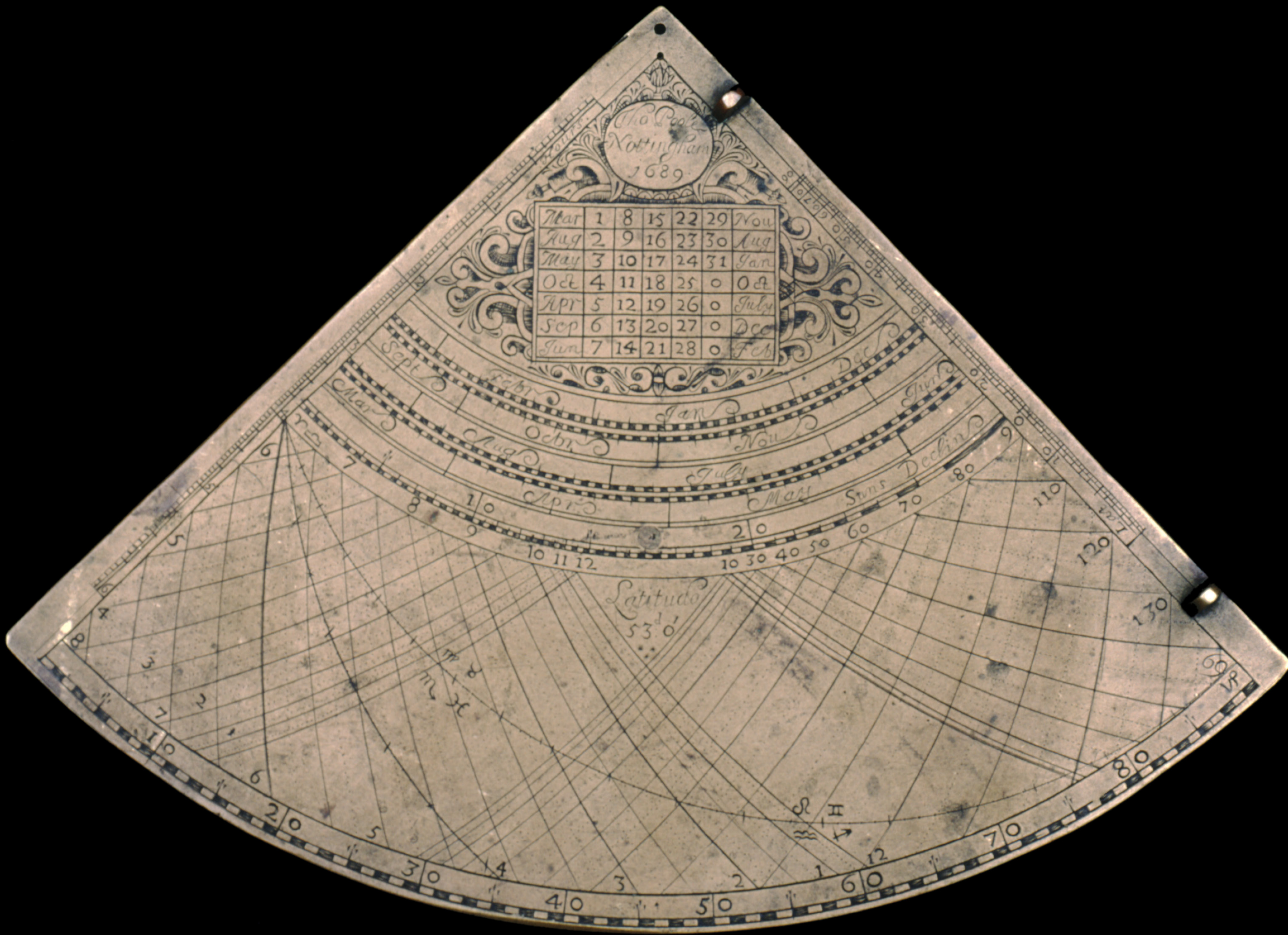
Wh.6145

'Lot number 63, a particularly fine and unusual horary quadrant to the design of Edmund Gunter. And I can open the bidding at eight thousand pounds, at seven thousand pounds. Thank you sir, seven-five with you. Now eight thousand back with me…' Little did I realise in October 2006 as auctioneer Nick Orchard opened the bidding on this quadrant, at Christie's South Kensington sale rooms, that less than a year later I would be joining their ranks as a junior specialist. I waited patiently for things to quieten down before raising my paddle on behalf of the Whipple: Liba always issued us with strict instructions when going to auction not to bid too early. But she also trusted us to use our discretion and go one bid higher than planned in case we were wrong-footed by the bidding increments.

One of the highlights for me when working at the Whipple was the arrival of a new auction or dealer's catalogue, going through it and highlighting possible acquisitions for Liba's approval. The decorative engravings (including two students with a globe) to the edges of the quadrant, along with the astronomy and signature of a provincial English maker, made this unlike anything in the Whipple's collection. In my final weeks at the Museum I discovered the source of the astronomy was from Edward Sherburne's *The sphere of Marcus Manilius* (1675), a copy of which had recently been acquired from the famed Macclesfield sale at Sotheby's. Had we known the connection to Sherburne at the time we may have decided to set our maximum bid a bit higher…

'At twelve thousand pounds, the bid is yours!' As the hammer came down, I shakily raised my paddle. The bidding had risen perilously close to the Whipple's maximum bid, and the buzz of the auction room had made me both excited and nervous. Hundreds of auctions and tens of thousands of lots later, the nerves may be gone but I still think back to this quadrant that set me on the path to my career.

James Hyslop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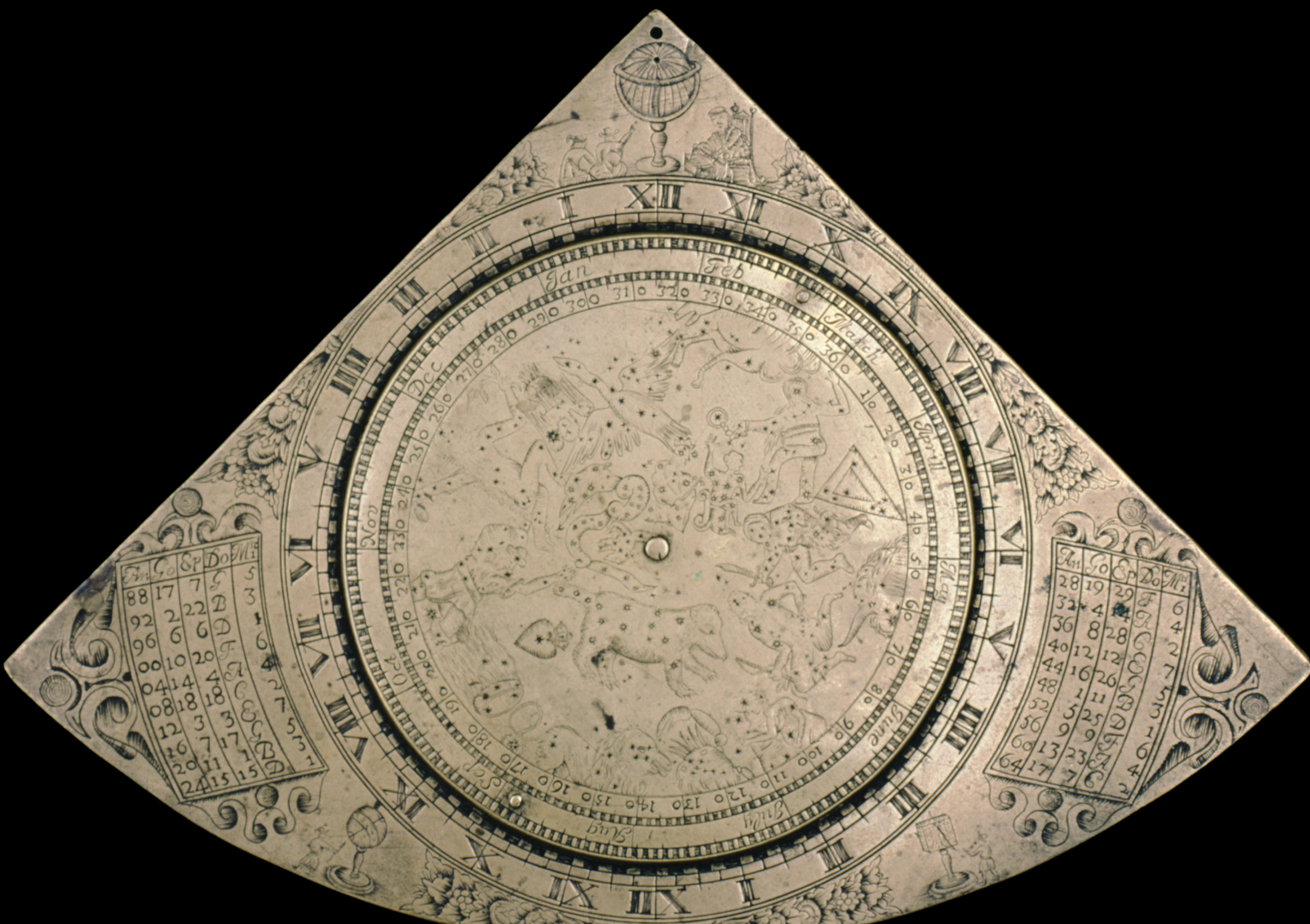
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Papier-mâché model of a silkworm (*Bombyx sericaria*), by Auzoux, French, *c.* 1900

Wh.6165

Having a good relationship with the trade is essential to the development of any collection, and the Whipple is fortunate that Liba had an excellent relationship with Trevor Waterman, who for most of her directorship was the leading dealer for instruments in the United Kingdom. Of all the objects that came from his London dealership, Trevor Philip and Son Ltd, this model perhaps exemplifies that relationship best. The Whipple was the first to be offered the Auzoux model of a 'caterpillar' just before the largest art fair of the year, TEFAF in Maastricht. A price was quickly agreed, with the Whipple applying for and securing a grant from the PRISM fund, and the 'caterpillar' went to fair with a red sticker, where it was much admired by jealous collectors.

The 'caterpillar' soon proved to be of a rather special type, being correctly identified as a silkworm by Margaret Olszewski as part of her research into Auzoux (see the entry for Wh.5765 in this volume).

James Hyslop

Papier-mâché human anatomical model, by Auzoux, French, *c.* 1900

Wh.6361

Perhaps the most impressive Auzoux model acquired during Liba's tenure as Director of the Whipple Museum. Known to Museum staff as 'Marcel', this extraordinary object contains dozens of removable parts and hundreds of numbered labels to aid the study of human anatomy. The model shows the musculature and bones of the human figure, the cranium opens to reveal a removable brain, and both sides of the face detach separately. The torso disassembles to expose detachable organs, and both arms and legs can be completely removed from the body.

The Editors

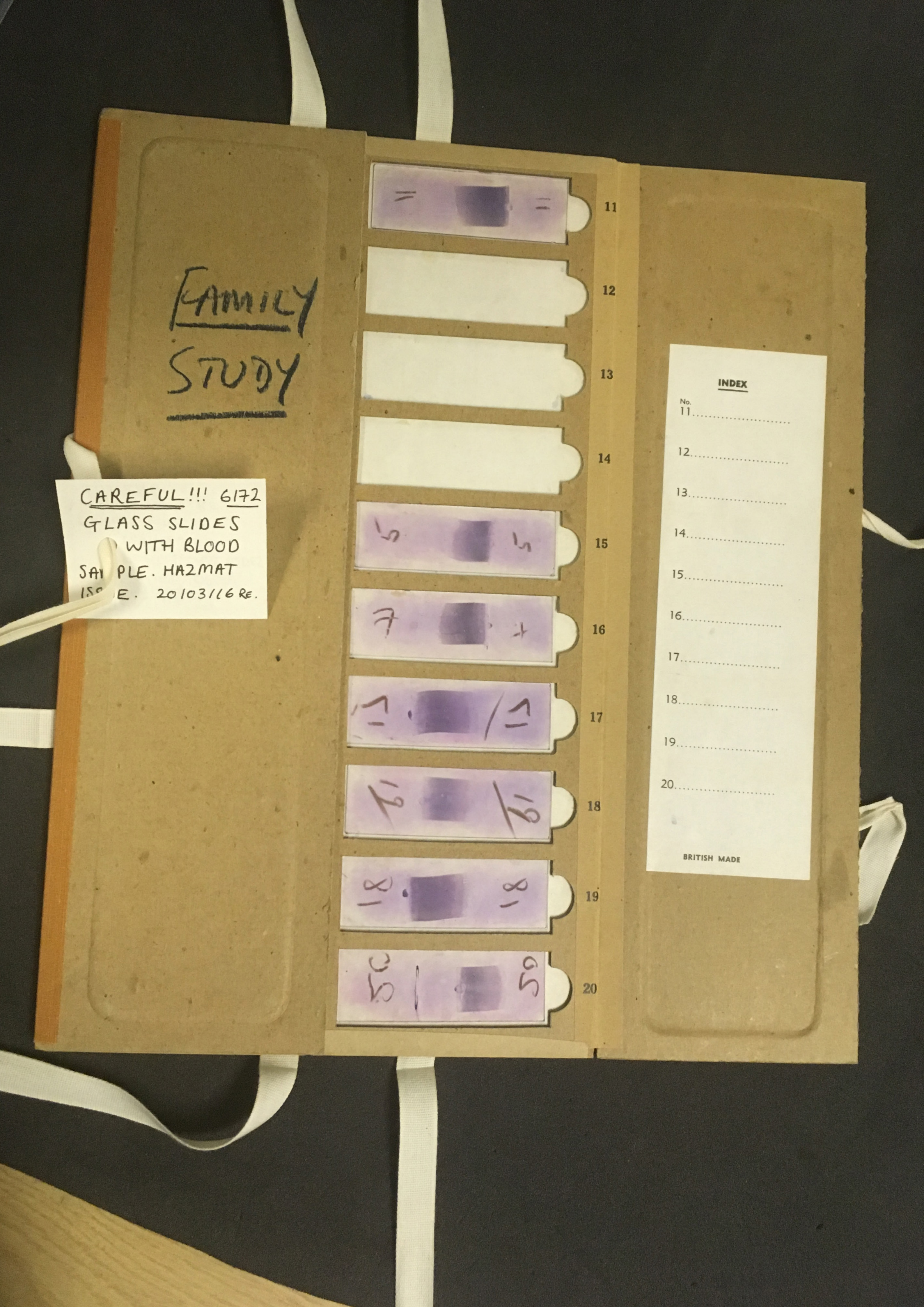
Material belonging to the biochemist, chemical pathologist, and blood specialist Hermann H. Lehmann, mid- to late 20th century

Wh.6172

Hermann Lehmann (1910–85), a German emigre who settled first in London and then in Cambridge, was a biochemist and chemical pathologist. He was best known for his work on abnormal haemoglobins. His collection of abnormal haemoglobins that he identified from blood samples from around the world was the centrepiece of his Unit's work that became a World Health Organisation International Reference Centre for Haemoglobins.

The three boxes of archival material held by the Whipple Museum were donated by his wife. The materials contained in the boxes, although somewhat random at first sight, provide a unique insight into the material practice of blood collecting and analysis as well as into Lehmann's field, clinical, and teaching work more generally. There is a profusion of boxes and containers of different size and provenance, made of carton or wood, some custom made, others adapted to new uses, containing microscope slides, photographic glass plates or transparencies. Some of these are in their original Kodak or Ilford boxes and unused. Others contain blood smears and are marked with numbers and letters. Of special interest are the different card-board folders and wooden storage boxes used to order, protect, and safely transport the slides (see figure). The collection also contains some photographs and correspondence as well as the black and red components of a series of hand-sized wooden haemoglobin models.

Soraya de Chadarevian



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BRITISH MADE

8-inch globe of the planet Mars, after the maps of Percival Lowell, by Ingeborg Brun, Denmark, 1913

Wh.6211

Like a great many people, I owe my entry into the museum sector to Liba. This debt amounts to a great deal more than her merely giving me a summer internship and then, eventually, a job. What Liba really gave me and so many like me was a space in which to work with objects – time and freedom to research them, curate them, and write about them. Even as a relative neophyte, Liba encouraged me to investigate this enigmatic globe, which had been offered for sale to the Museum and which presented something of a puzzle to dealer and customer alike. Hand painted by a Danish artist, Ingeborg Brun, it represents in three-dimensions the Martian maps of the American astronomer Percival Lowell. Not even a century old when I first laid eyes on it, this globe presents an utterly alien world. Rather than a dead and near-featureless expanse, Brun depicts a vibrant living planet, crisscrossed with dense green vegetation and peopled by an industrious race of busy canal-building engineers.

My attempt to understand and explain this world sent me deep into a story almost too implausible to believe, yet too serious to dismiss. Mars's spider's web of fine, straight lines, Lowell claimed, were *literal canals*, manufactured in an immense network by purposeful Martians desperately seeking to irrigate their cold, arid planet. Whether his contemporaries thought of this idea as fanciful or electrifying it was certainly hard to ignore, and the debate over evidence for life on Mars raged on well into the 20th century, taking in a vibrant world of astronomers, journalists, artists, and an always interested public. Much later these stories also took me in, leading to a PhD on the subject and, eventually, my first book – a journey of exploration that all began with an invitation from Liba to investigate a single, curious object.

Joshua Nall

MARE
ERYTHRAEUM
STAGNUM
PEGASEUM
AURUM
AURORAE
SINUS
CAICUS
SOLIS
LACUS
NECTAR
FONS
JUVENTAE
SABAEUS
SINUS
SINUS MARGARITIFER
HYDRAOTES
HYDASPES
JAMUNA
DODON
GANGES
CHRYSORRHOAS
OLEASTER
LUCUS
LYSIS
LUCUS
LUNAE
KRITH
URANIUS
INDUS
OXUS
SILOE
FONS
NILOKERAS II.
NILOKERAS I
TAPIS
JOBARES
ALANDER
ENGEDDI
CRANEUM
ACADINUS
FONS
TEMPE

Folding boxwood gauging rule, by Henry Sutton, English, 1655

Wh.6239

This unassuming little wooden ruler is – in my humble opinion – one of the greatest treasures in the Whipple Museum. In fact it is so unassuming that it remained in use (solely for its inch scale) until just before it was donated to the Museum, in 1998. Alongside the inch scale there are various other unequally divided scales, and an inscription:

> Mr Iohn Reynolds Diagonall Line for gauging of Cask &c | Henry Sutton fecit 1655

This is what makes the rule so special: there is no printed account of this instrument, so without its survival we would have had no idea of its existence.

From various other sources we can reconstruct its history and context quite precisely: in the 1640s the government introduced new Customs and Excise regulations in order to raise money to fight the King and his forces in the Civil Wars. This quickly put pressure on the measurement system in use to assess the volumes of the casks that were used to transport goods. These measurements turn out to be surprisingly complex – and to compound matters, a group including John Reynolds discovered that the standard measures that had been kept for centuries at the Guild Hall were in fact erroneous. This rule, made in collaboration with the brilliant instrument maker Henry Sutton, is Reynolds' attempt to solve the problem – not by fixing the standards, but by inscribing accurate scales on a pocket rule that could be carried around the country to measure casks.

Boris Jardine

Set of twenty-four wax models of apples, made for the Botanical Institute of the Royal University of Turin, Italian, *c.* 1850

Wh.6267

Soon after arriving at Cambridge to undertake an MPhil in hps in 2009, I briefly worked for Liba, sorting out image reproductions of an ancient rose of the winds held in the Vatican Museums. Liba thought I should make the most of my knowledge of Italian and asked me to find out something more about a then 'mysterious' object held in the Whipple, a pomological set of twenty-four wax models of apples. The models were displayed in a 19th-century ebony case, bearing the inscription 'Istituto Botanico. Regia Università di Torino'. The museum label suggested some association with Francesco Garnier Valletti (1808–89), an artisan who produced 'hundreds of varieties of wax fruit in Turin during the late 19th century'.

The second part of the 19th century was a crucial moment in Italian history, marking the time of the Italian Risorgimento and national unification process. In 1861, Turin became the first capital of Italy: agricultural improvements were part of a broader discourse on modernization sponsored by Camillo Benso Conte di Cavour (1810–61), a Piedmont statesman who supported Italian national unity. Cavour encouraged agricultural fairs and promoted the creation of local assemblies and itinerant chairs to foster agronomic knowledge and expertise. It is in this commercial context that models of apples, pears, grapes, peaches, apricots, and figs were used, so that potential customers could get a sense of what the seeds and trees they bought would yield at a later time. Valletti, to whom the city of Turin has dedicated a museum, worked at exactly this time, practicing a discipline called 'artificial pomology', a series of techniques for the faithful reproduction of fruit varieties.

The artisan prepared a mixture of alabaster dust, natural waxes, plaster, vegetal ash and colofonia, a natural yellow resin derived from conifer resin and largely employed in the fabrication of paints. This combination was extremely durable and less affected by changes in temperature

and humidity. He would then cast this compound in different moulds, according to which cultivar he wanted to reproduce. He would use each mould several times, allowing a serial reproduction.* Naturalistic drawings, whose scientific accuracy revealed a thorough knowledge of botany and agronomy, aided the making of three-dimensional models. Valletti was extremely talented in capturing key features (skin color, lenticels, cuticle, and petiole) which allowed to distinguish between different cultivars.

Despite Valletti's prominence in artificial pomology, the models in the Whipple Museum cannot be attributed to him. Indeed, their bodies are made in wax, not mixed materials. Nevertheless, the suggestion and association of this object with the Piedmont artisan is not surprising. Valletti was the most distinguished wax-modeler in Piedmont at that time. His models were highly appreciated as teaching devices, to facilitate pomological classification, as commercial tools, in the context of agricultural fairs and, finally, as works of art. Going beyond the attribution, this object tells us a great deal of the intersection between botanical and agronomic expertise, commercial imperatives, and political propaganda, not only in Turin, but also in the newly founded Kingdom of Italy.

Lavinia Maddaluno

* Daniele Jalla (ed.), *Il Museo della Frutta 'Francesco Garnier Valletti'* (Turin: Officina Libraria, 2007), pp. 109–15.

Electrite portable electrocardiograph, by Cambridge Instrument Company Ltd, English, 1950

Wh.6373

An electrocardiograph is a medical instrument that records the electrical activity of the heart. Physiologists first discovered the electrical wave that accompanies the human heartbeat at the end of the 19th Century. However, it wasn't until Dr Willem Einthoven used a string galvanometer to record it in 1903 that a practical instrument producing a precise electrocardiogram was possible.

Einthoven's whole electrocardiograph apparatus was large and awkward. It filled a room, weighed over 600lbs, and required five people to operate. It also required patients to travel to the instrument and immerse their limbs in saltwater baths to transmit the electrical current of their heart. However, electrocardiographs revolutionised cardiology and hugely improved the diagnosis and treatment of heart problems. In recognition, Einthoven was awarded the Nobel Prize in Physiology or Medicine in 1924.

Based on Einthoven's design, Cambridge Scientific Instrument Company developed a marketable electrocardiograph, selling its first in 1911. Over the next few decades, the Company continually redesigned it, reducing its size and weight, and transforming it from a cumbersome, specialist piece of hospital equipment to a portable instrument easily used by any medical professional.

At 13¼" x 8½" x 11" and 30lbs, this 1950s Electrite demonstrates what a transformation this was. In addition, the Electrite was the Company's first direct-writing instrument, which meant that its results were available instantly.

This particular Electrite also tells another story. Like the many other 'orphan' objects in museums worldwide, it was found in storage, with unknown origins, acquired before increased professionalisation of the industry in the late 20th century when acquisition procedures were tightened. As museums across the country strove to improve their collections management, so too did the Whipple Museum. Liba's focus on 'back of house' activities led to staff undertaking an audit of the collections in 1998, assigning temporary numbers to unaccessioned objects until they could be researched and hopefully reconciled to old paperwork. This Electrite was assigned a temporary number until it was formally accessioned in 2009. Although it was not 'acquired' during Liba's tenure, it is certainly when it gained its official place in the collection.

Morgan Bell

McFarlane's Calculating Cylinder, by James Macfarlane, Scottish, *c.* 1835

Wh.6381

As a teacher at a mercantile academy in Glasgow, James Macfarlane (1793–1848) followed conventional practice in expecting his students to undertake a range of exercises in addition, subtraction, multiplication and division, using both raw numbers, and in money, weights, and measures. His 'calculating cylinder' was intended as a teaching aid:

> The Machine consists of a small Cylinder, having three distinct parts revolving separately, on which are inscribed several series of numbers, calculated to propose and answer questions to an almost indefinite extent in the first four rules of Arithmetic – in the rules of Reduction, Proportion, Practice, Interest, Vulgar and Decimal Fractions, &c. From the very novel and interesting manner in which the Cylinder casts up the result to each question which may be proposed by it, without the possibility of a wrong answer being given, the attention of the pupil is naturally arrested, and his curiosity excited. Hence being induced to try the accuracy of the different results, he unconsciously gains a knowledge of the most essential parts of the science, and converts what is but too often regarded as a dry and irksome task, into a pleasing and attractive amusement.
>
> To teachers who instruct their pupils in classes, the Cylinder must be of the greatest importance. By it, with the greatest ease and facility, questions can be proposed to a very numerous class, or to several classes, though in different rules, and every error immediately detected, by a method which has for its recommendation simplicity and infallibility.[*]

The device could provide 'upwards of a million' possible questions,[†] but

[*] James Macfarlane, *Rules, Directions and Examples illustrating the use of Macfarlane's Calculating Cylinder, designed to promote the instruction of youth in the elementary principles of arithmetic. Adapted to public and private tuition* (Glasgow, 1833); 2nd edition improved and enlarged (Edinburgh [1837?]; 3rd edition improved and enlarged (Edinburgh, 1837).
[†] *Glasgow Herald*, Dec. 1833 – reprinted with acknowledgement in *Belfast Newsletter*, 10 Dec. 1833 and *Northern Whig* (Belfast), 12 Dec. 1833.

it was not intended to be a universal calculator, and does not function as such. Macfarlane achieved that end with his finely divided 'Calculating Planisphere' of 1841.[‡] This example of the Calculating Cylinder is made to the 'improved' design, being sold for ten shillings (50p) from November 1834.[§] Comparison of surviving examples indicates that the paper scales were re-printed and re-issued several times – the title statement being re-set in differing fonts. An example in the Science Museum does not include 'Glasgow' in the title box, and was probably produced in London, where Macfarlane was resident in the early 1840s, and from where he launched the 'Calculating Planisphere'.[¶]

David J. Bryden

‡ 'The Calculating Planisphere', *The Penny Mechanic and Chemist* 1 (1841), p. 391; see also 'The Calculating Planisphere', *The Inventors' Advocate and Journal of Industry*, 5 (1841), p. 270 and *The Times*, 21 Oct. 1841 – cited from the abridged report in *The Year Book of facts in Science and Art* (London, 1842), p. 18. There is an example in the Smithsonian National Museum of American History, Washington, D.C., inv. no. 1990.0539.42.
§ *The Scotsman* (Edinburgh), 29 Nov. 1834.
¶ Science Museum: inv. no. 1970-172. Note also that the British Library copy of the 3rd (1837) edition of the *Rules* has added in ink below the author statement '53 Green Street, Stepney'.

‘Astronomical Rotula’, by George Margetts, English, after 1779

Wh.6382

George Margetts (1748–1804), the fourteenth child of a wheelwright, was born in Old Woodstock (a parish within the municipal borough of Woodstock), Oxfordshire. Displaying an early aptitude for mathematics he was intended for a career in commerce, but the death of his father prevented this and he was apprenticed to one of his elder brothers to learn the craft of the wheelwright. This he did with success, but soon became interested in astronomy and clockwork, building a tellurium when he was about eighteen subsequently cannibalised for the building of clocks. Inevitably in the tiny community that was Woodstock, Margetts’ precocious abilities came to the attention of the Duke of Marlborough who supported him, paying for him to obtain ‘a regular knowledge of watchmaking’ in London from 1771 onwards.*

Margetts’ title for this paper tool, *The New Invented Astronomical Rotula*,† suggests that he had been inspired by, and was seeking to distinguish his work from, that of James Ferguson, whose *Rotula* of 1742 had been reissued, revised and enlarged, in 1760, complete with an accompanying booklet, as *The Astronomical Rotula, Showing the Change and Age of the Moon, the Motions of the Sun, Moon and Nodes*.‡ The similarity between the two projects is striking, as is the fact that the table of new moons on Margetts’ *Rotula* runs from 1763 onwards, although he may not have completed and published the device until the 1770s. Certainly it is to be seen as a stage in the development of Margetts’ astronomical watches which, without being identical, are close to the *Rotula* in layout. The earliest of these known has

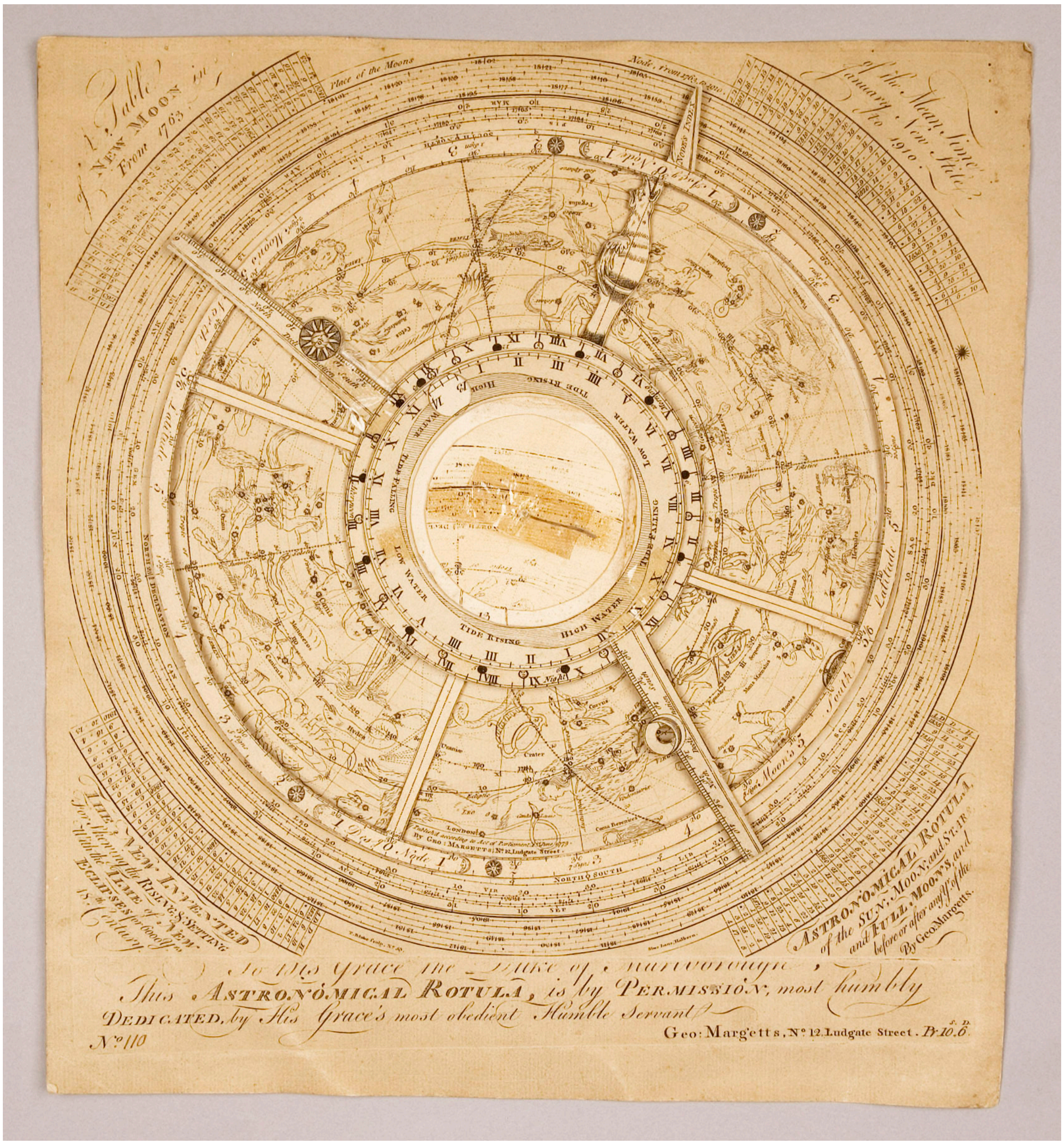
* Quoted in Jonathan Betts, *Marine chronometers at Greenwich* (Oxford: Oxford University Press, 2017), p. 231.

† The Whipple Museum’s copy of the *Rotula* was purchased from Bonhams in 2009, having previously been in a private collection since at least 1970. It was first published in 1971, when it was already without the central tide disc. See Anthony J. Turner, ‘New light on George Margetts’, *Antiquarian Horology* 8 (1971), pp. 304–16.

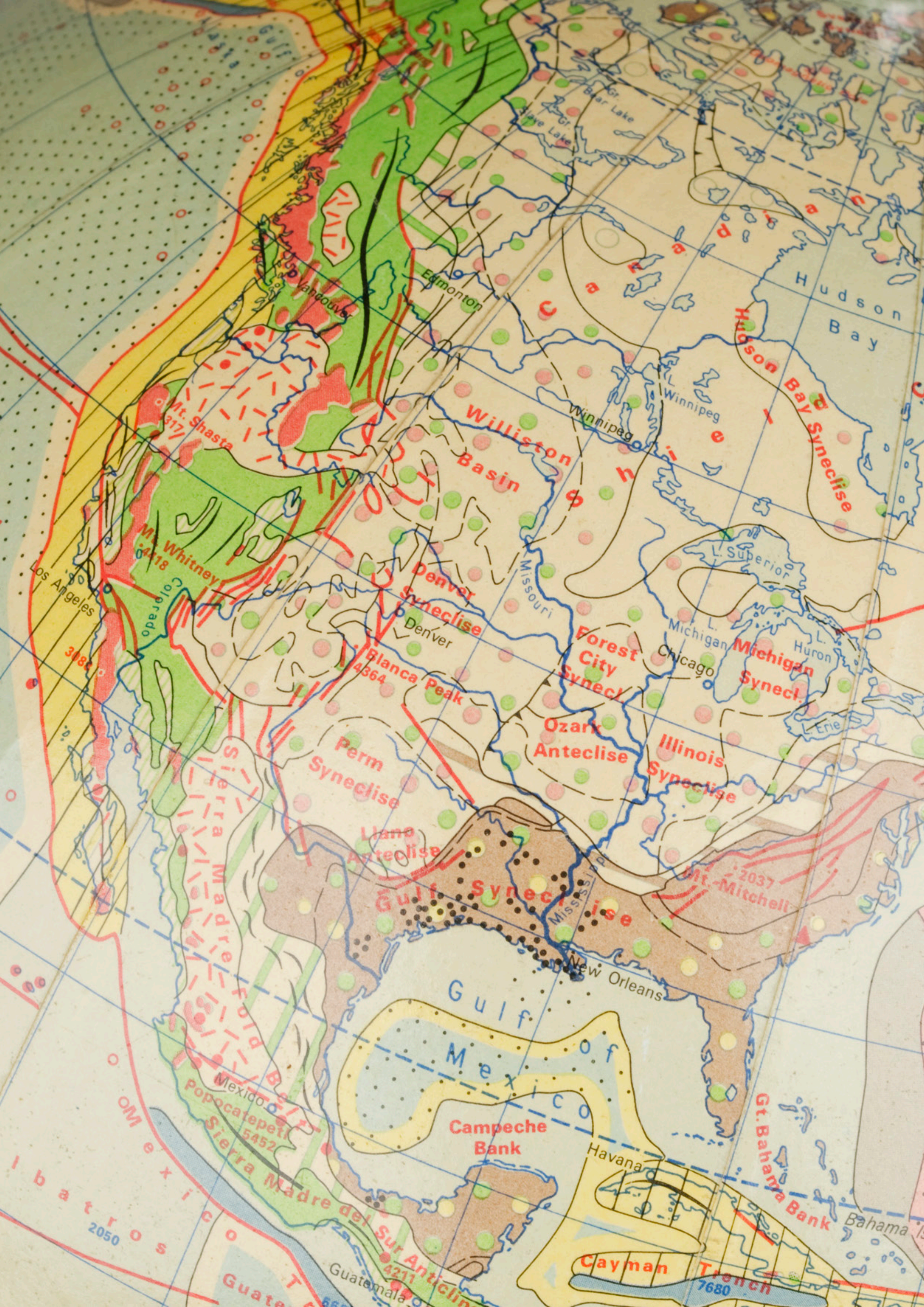
‡ John R. Millburn, *Wheelwright of the Heavens: The Life and Work of James Ferguson, FRS* (London: Vade-Mecum, 1988), pp. 292–93.

a case hallmarked 1778,[§] the year before Margetts became a member of the London clockmaker's company by redemption. Before then however, Margetts had published a user's manual for the *Rotula* which makes the relation between the two instruments explicit as the title states that it is 'made on the same construction and serving to illustrate and explain his new invented astronomical Clocks and Watches'.[¶]

Anthony Turner



§ British Museum inv. no. 1898,1217.1.
¶ Turner, 'New light on George Margetts', *op. cit.*, p. 312.



Gr. Bear Lake
Gr. Slave Lake
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Hudson Bay
Hudson Bay Syneclise
L. Winnipeg
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Williston Basin
Mt. Shasta
Mt. Whitney
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Los Angeles
Colorado
Denver Syneclise
Denver
Missouri
Blanca Peak
4364
Forest City Syneclise
Chicago
L. Superior
L. Michigan
L. Huron
Michigan Syneclise
L. Erie
Ozark Anteclise
Illinois Syneclise
Perm Syneclise
Llano Anteclise
Gulf Syneclise
Mississippi
New Orleans
2037
Mt. Mitchell
Gulf of Mexico
Campeche Bank
Havana
Gt. Bahama Bank
Bahama
Cayman Trench
7680
Sierra Madre Fold Belt
Mexico
Popocatepetl
5452
Sierra Madre del Sur
4211
Guatemala
2050

‘Tectonic globe of the Earth’, showing Russian theory of geological tectonics, by Kurt Ziesing, East German, 1972

Wh.6383

Shortly after I joined Christie’s in 2007, Liba (and my co-editors) came to one of the views before an auction to inspect a potential new acquisition. Later than day, over lunch, plans for the new Globes Gallery were discussed. We chatted about what might be coming up at auction in the near future (see Wh.6503) and what rare and curious globes might be in private collections. I confess that at the time I had no idea if such a thing was available or even existed, but asked if the Museum had a geological globe?

Very soon thereafter the Whipple triumphantly told me of their latest acquisition, a Russian geological globe acquired from an antique dealer in Amsterdam. When I saw it in person it was love at first sight. In 2015 I finally tracked down another example and was able to bring it to auction. A year later I was lucky enough to get a copy for myself. It’s the only globe that I own and it sits on my desk in the office, where every so often I look at it and am reminded at how often Liba was ahead of the curve with collecting trends.

The globe itself represents an experiment in cartography. Kurt Ziesing and his mentor Wolfgang Pillewizer were interested in thematic mapping and the benefits of 3D representation. Using tectonics as a case study, Ziesing and Pillewizer show different stages of geosynclines, which were trough-like depressions in which sediment accumulated and provoked the crust to subside. Data for the globe was compiled from Russian atlases, and so the tectonic theory that Ziesing and Pillewizer represent is Russian. Continental drift was not accepted in Russian geology until the 1980s – so, rather than showing tectonic plates that move according to horizontal displacements, this globe represents displacements occurring by vertical movement.

James Hyslop

Wax models of starfish development, by Adolf Ziegler, German, 1882

Wh.6388–98

These intriguing objects were once a routine part of higher education in zoology, but have become distanced from most viewers today. The topic was always rather specialized, and the medium has grown unfamiliar too. In the three wooden cases, all 42.5cm wide, we see formed lumps of hard wax that rest on cotton wool: with an 85-mark price tag, these were precious preparations in their own right. The label in German and Latin identifies them as representing 'Development of *Asterina gibbosa* Forbes'. The numbers in the box tell us to read from top left to bottom right, or day 4 to day 10. All magnified 250 times, most of the models are in pairs, with the second of each cut away to reveal schematically coloured internal parts. The five arms that develop signal that this is a starfish; the species is common in the northeast Atlantic and Mediterranean.

At a time when wax embryos were associated with the secret cabinets of commercial panopticons, these models by 'Dr. Ad[olf] Ziegler, Freiburg i[n] Baden' 'after Professor Dr. H[ubert] Ludwig' illustrate how hard the former physician Ziegler worked to maintain academic status. Flaunting their two doctorates and one professorship, he advertised the series as after the prize-winning 1882 article in the top journal by the Giessen zoologist Hubert Ludwig. Ziegler's son Heinrich Ernst, also a zoologist, showed his colleagues the models at a congress, while Ludwig's published notice praised the 'masterful skill' with which the father's 'excellent teaching aid' made the shape changes vivid. The colours (ectoderm, yellowish; stomach, white; enterocoel, red; hydrocoel, blue) 'significantly' aided understanding.

Nor was Adolf Ziegler the only one cultivating specialist credentials. The models display Ludwig's fascination with the emergence of form, here especially of radial from bilateral symmetry, that he observed in specimens raised at the Naples Zoological Station. But Ludwig, though an evolutionist, avoided controversy over Darwinism. His narrow investigations made him the expert on echinoderms, but hardly addressed the big questions about the shape and mechanisms of evolution, let alone 'man's place in nature'.

From Germany, the international centre of research, Ziegler models were exported worldwide. This set was bought, probably in the 1880s, for students in the Cambridge school of morphology, where Ernest MacBride extended Ludwig's inquiries into *Asterina gibbosa*. To judge from the condition, the Zoology Department employed this series less than those of the workhorses, frog and chick. Sydney Smith, who lectured on embryology and promoted history of science, staged a rescue when 'the destructive advance of scientific progress' reached the Elementary Laboratory in the 1960s. He urged his students to compare the models with Ludwig's plates, and so to appreciate 'what a good deal of work the Ziegler firm must have done to achieve a plastic realisation from the sections'. Around 1970, they moved from Smith's office to a basement store in the Museum of Zoology. Around 2000, historians of science used them to highlight the significance of wax as a medium of communication even in the great age of print. Liba Taub, who did so much to build up the Whipple Museum's collection of models, accepted the transfer in 2009.

Nick Hopwood

Collapsible terrestrial globe, by Betts, English, *c.* 1860

Wh.6486

From the 17th century globes were used to demonstrate and teaching the basics of geography and astronomy. Most were relatively small and could not be used with more than a handful of pupils at a time. They were also expensive and therefore prestigious to own. By the beginning of the 19th century a pair of terrestrial and celestial globes had become almost standard furnishings of a gentleman's library. In 1798 the Anglo-Irish author Maria Edgeworth asked rhetorically:

> Might not a cheap, portable, and convenient globe, be made of oiled silk, to be inflated by a common pair of bellows? Mathematical exactness is not requisite for our purpose, and though we could not pretend to the precision of our best globes, yet a balloon of this sort would compensate by its size and convenience for its inaccuracy.[*]

In the late 1820s the pioneer of man-lifting kites, Bristol school proprietor George Pocock, designed and marketed large terrestrial and celestial balloon-type globes, explicitly intended for teaching groups of pupils. In 1827 he floated the idea of a 'a *flexible globe*; composed of silk or other light material; capable of being folded or compressed in a small compass when not in use; and either by inflation like a bladder, or by joints of wire or whalebone, on the principle of an umbrella, contrived to be expanded to its globular shape when required.'[†] He patented the design in 1830, and they were widely advertised in Britain, with a Bavarian patent taken out the following year.[‡] Pocock's son-in-law, G. M. Gilbert exhibited examples at the 1851 Great Exhibition, when he was still marketing inexpensive 6, 9, and 12 feet circumference inflatable globes.[§] About this time the London map publisher John Betts first began to produce collapsible paper globes.[¶] In 1856 he registered a patent for 'improvements in the preparation or manufacture of artificial spheres'.[**] Betts chose not to pay the £50 stamp duty payment required after three years, and therefore technically lost his monopoly rights.[††] However, he and his successors long marketed the design as 'patent'. As manufactured, Pocock's design used a pump to inflate the globe. In contrast Betts utilised well-proven umbrella technology to unfold and maintain the shape of his collapsible globes.

The geography of the Betts portable patent globe was frequently updated, and the design was deservedly popular. Educational publishers George Phillips & Son Ltd were still marketing the Betts patent globe after the Great War.[‡‡] An example of the Betts collapsible 'umbrella' globe dating from *c.* 1880 is in the founder's collections,[§§] but its condition is such that frequent erection is inadvisable. This example was acquired so that the educational advantages of a cheap globe could be properly demonstrated. It is an early example: on the Australian continent, Brisbane is within New South Wales, not yet the capital of the state of Queensland, founded in 1859. On the north of the American continent, note 'RUSSIAN TERRITORY': the United States of America purchased what is now Alaska from imperial Russia in 1867.

David J. Bryden

* M. Edgeworth, *Practical Education* (London, 1798), p. 421. This influential work was frequently reprinted: 1801, 1811, 1815, 1822, 1845.

† Undated letterpress handbill pasted into the front cover of the copy of G. Pocock, *The Aeroplaustic Art, or Navigation in the Air by the Use of Kites or Buoyant Sails* (Bristol, 1827), University of Glasgow Library, Sp. Coll. BG46-a.6. See also *Mechanics Magazine* 7 (1827), p. 137.

‡ British Patent Woodcroft 5894 (1830), 'Making Globes for Astronomical, Geographical and other purposes'. The specification outlined, discussed and illustrated in *The Register of Arts, and Journal of Patent Inventions*, new series 4 (1830), pp. 293–95 + plate 20, fig. 5. For an example Bavarian manufacture, see Royal Museums Greenwich, inv. no. GLB0203: The cartouche includes the phrases: 'KOEN. BAYER. PRIVILEG. PNEUMATISCH PORTATIVER ERD-GLOBUS', 'Nach der Erfindung von Pocock'.

§ [Great Exhibition of the Works of Industry of all Nations], *Official Descriptive and Illustrated Catalogue*, vol. 1, p. 423 (Class X, item 234); *Exhibition of the Works of Industry of all Nations, 1851: Reports of the Juries* (London, 1852), p. 308. The description by the Jury is clearly of a Pocock globe. That Gilbert owned such rights to Pocock's patent designs as still existed, is clear from his also exhibiting a model of the kite-drawn 'charvolant', see ibid, p. 309. For Gilbert's marriage see *Bristol Mercury*, 9 Sep. 1828. See also the hand-bill headed: *Applications respecting the Charvolant*, copy pasted before the title pages of G. Pocock, [2nd edition] (London, 1851) – copy in University of Michigan Library A 1,003,681. Gilbert, in Ealing, and A. Pockock, in Bristol, sold 'patent portable juvenile kites', whilst the 'patent portable globes' available in models of 6, 9 and 12 feet in circumference from 10s.6d to £2.2s. were sold by Pockcock in Bristol and in London by an agent named Houghton, at 162 Bond Street.

¶ [John Betts], *A Companion to Betts's Portable Globe and Diagrams* (London, [1850]). The back cover r & v is headed 'NEW PUBLICATIONS' and describes eight of Betts's publications – the last being for his improved educational maps – listing those which have been published and those 'in a forward state. May 1850'.

** British Patent 1338 (1856), 'Improvements in the preparation or manufacture of artificial spheres'. The cartouche on Wh.6486 reads: 'By the Queen's Royal Letters Patent, Betts's New Portable Terrestrial Globe, Compiled from the Latest and Best Authorities, London John Betts 115 The Strand'.

†† *London Gazette*, no. 22290, 22 Aug. 1859.

‡‡ Elly Dekker, *Globes at Greenwich: A Catalogue of the Globes and Armillary Spheres in the National Maritime Museum, Greenwich* (Oxford: Oxford University Press, 1999), pp. 276–78, 445–47; J. T. Lanman, 'Folding or collapsible terrestrial globes', *Der Globusfreund* 35/37 (1987), pp. 39–44.

§§ Wh.0438, acquired by R. S. Whipple in 1927: https://collections.whipplemuseum.cam.ac.uk/objects/12335.

9-inch 'Grand Sohlberg' glass celestial globe with miniature terrestrial globe inside, Swedish, late 19th century

Wh.6503

A VERY FINE and unusual celestial globe issued in Stockholm for use in schools. A handful have appeared on the market over the decades, but the stars applied in paint to the glass don't often survive as intact as they do on this copy. Only fifty were made and originally carried a price of 118 Kr (of which the government paid 20). The globe was designed to be half-filled with ink or litmus-coloured water, to show the selected region's horizon; the water could be drained and replaced through the valves. Alas the valves are no longer fully water-tight, and before this globe went to auction (whence it was acquired by the Whipple) it leaked all over my desk.

James Hyslop

Astatic galvanometer, Ruhmkorff type, by J. Carpentier, French, *c.* 1880*

Wh.6499

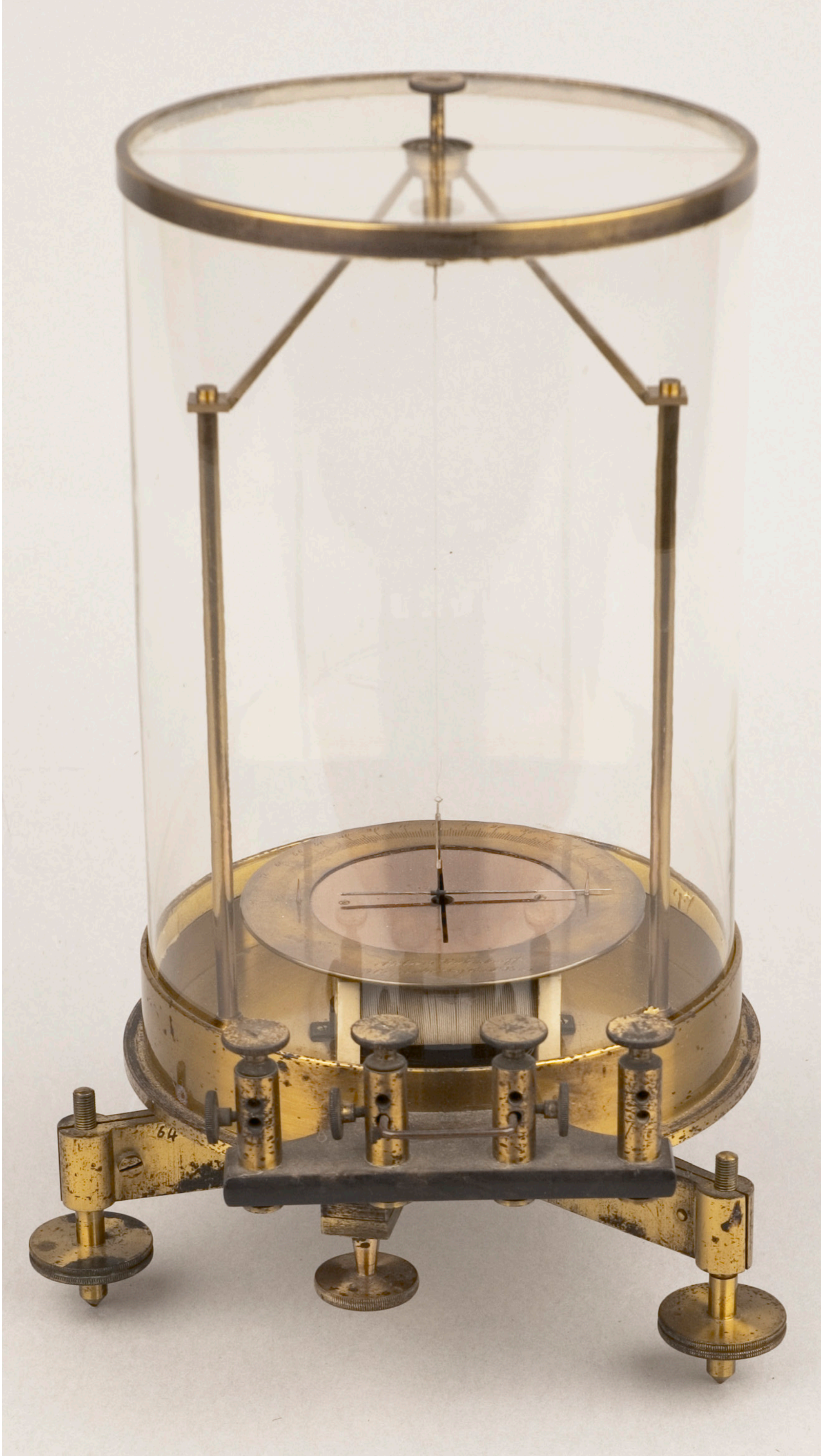
There are few scientific men, and presumably no electrical engineers, who have not been called upon to use a galvanometer at some period of their lives. Such being the case, it may be of interest to consider for a little while the history of an instrument which is of such importance.

The first use of the word 'galvanometer' in English was, apparently, in a paper by a Dr Bischoff published in 1802 and entitled 'On Galvanism and its Medical Application'. The paper gives a survey of the knowledge of galvanism and mentions the work of Volta and Ritter on the thermopile. A long description is devoted to 'The Galvanometer.' This instrument is in effect a gold leaf electrometer, with an arrangement for measuring with a micrometer screw the distance between the gold leaf and the charged sphere deflecting it. After Volta's work there appears to have been little advance in the study of electrical phenomena, apart from the medical side, until the great discovery in 1820 by Hans Christian Oersted that an electric current could deflect a compass needle. On learning of this discovery, Ampère commenced his investigations and showed that two electric currents can exert mechanical force upon one another. He also propounded the laws governing the action of electric currents upon magnets.

In 1820 Schweigger suggested the winding of several turns of wire round the needle to increase the force acting upon it, calling the arrangement 'an electro-magnetic multiplier'. Cumming and Kaemtz carried out careful experimental work, which showed that the effect of the current on the needle is proportional to the number of turns in the wire surrounding the magnet. Cumming suggested that a magnet should be placed below the suspended magnet to reduce or neutralize the local magnetic field.

* This account is extracted from a talk given by Robert Stewart Whipple in January 1934 at the twenty-fourth annual exhibition of the Physical Society, and subsequently published as: R. S. Whipple, 'The Evolution of the Galvanometer', *Journal of Scientific Instruments* 11 (1934), pp. 37–43.

He speaks of his instrument on several occasions as a galvanometer, and this must be one of the earliest uses of the word when applied to the instrument as it is understood today.



A second needle, with its poles reversed in direction, was added to the moving system by Nobili at the suggestion of Ampère. Although the suspended astatic magnet form of galvanometer was in general use for many years as a detector for showing the presence or direction of an electric current, it was not generally used for measuring the intensity of a current. Ritchie suggested in 1830 the employment of glass threads for suspending the galvanometer magnet, pointing out that by using this material it would be possible to compare the intensity of two currents by the relative deflection of the needle. The tangent or sine galvanometer, invented by Pouillet in 1837, became the instrument for the measurement of current. It consists of a moving magnet, either pivoted or suspended, mounted in the centre of a coil consisting of one or more turns of copper wire wound on a ring about 30cm in diameter. Poggendorf showed that if the length of the magnet be small then the tangent of the angle of deflection of the magnet is proportional to the strength of the current.

Robert Stewart Whipple (1871–1953)

Table orrery, by Nairne & Blunt, English, *c.* 1783

Wh.6508

In the 18th century, the Newtonian system illustrated the order, regularity and law-based design of all creation. How did you bring these principles into your home? The answer was an orrery, a mechanical model illustrating the movements of the Sun, Earth, Moon and planets. This elegant orrery, small enough to fit on a tabletop, was intended for a small circle of viewers in a domestic setting.

In the later editions of *The Newtonian System of Philosophy*, a pioneering children's book first published in 1761, the precocious Tom Telescope explained the principles of astronomy using an orrery. Tom's fellow children – and especially Tom Wilson, a follower of Aristotle – had lots of questions for their youthful lecturer. Why do we see the Sun rise and set? What is the relation between the Moon and the Sun? What is an eclipse? These and many other questions could be answered with the orrery.

As the Whipple Museum collections show, orreries came in many different sizes, types and prices. The trade in philosophical instruments benefited from a new world of commerce in England. Tom Telescope's orrery, featured in the Newtonian System's 1794 edition, includes the planets all the way to Saturn, with the mechanism hidden within a tasteful wooden table. It did not, however, have an armillary hemisphere and was difficult to store. The same edition concluded with a list of 'Optical and Philosophical Instruments mentioned in this Book' that could be obtained at W. and S. Jones, a firm that appealed to consumers on a budget. Along with a reflecting telescope, an air-pump and an 'Air-Gun, for experiments only', the advertisement included orreries priced from one to ten guineas, depending on the quality of the clockwork gearing. In this way, the wonders of the heavens could be experienced first-hand.

Tom's lectures to the 'Lilliputian Society' took place in the country house of the Marquis of Setstar. However, the principal market for the Newtonian System was not the aristocracy or gentry, but the middle classes. Parents who bought the book to help their children avoid gambling and other low pursuits were unlikely to have purchased elaborate philosophical instruments. The fine orrery illustrated above certainly cost more than anything advertised in connection with Tom's lectures.

One of the Whipple Museum's finest acquisitions in recent decades, this orrery is well-finished and in a neoclassical style. Sold by the prominent London firm of Nairne & Blunt, but likely made in the workshop of Benjamin Cole in the decades on either side of 1783, it comes with a fitted pine box. This suggests that it was not intended for continuous, conspicuous display in a library or drawing room, but as an educational tool. It might have been used by a travelling lecturer, or perhaps by a private tutor in a wealthy household. In either case, the orrery served pre-eminently to convey the moral and religious lessons taught by nature. As Tom Telescope says, 'Do thou, O God! Support me while I gaze with astonishment at thy wonderful productions…'[*]

Jim Secord

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[*] All quotations are from Tom Telescope, *The Newtonian System of Philosophy: Adapted to the Capacities of Young Ladies and Gentlemen* (London: Ogilvy and Speare, [1794]).

Plaster phrenological bust of Pierre-François Lacenaire (1803–36), attributed to James de Ville, French, *c.* 1836

Wh.6510

A PLASTER BUST of the notorious French criminal Pierre-François Lacenaire (1803–36). In November 1835, Lacenaire was convicted of a brutal double murder and sentenced to death. A few days before the execution, the leading French phrenologist Pierre-Marie-Alexandre Dumoutier (1797–1871) visited Lacenaire in prison and took a plaster cast of his head. Dumoutier hoped that it would provide evidence to support a phrenological account of criminality.

Phrenologists believed that particular mental faculties were located within particular regions of the brain. These different regions, or 'organs' as phrenologists called them, could then apparently be identified by the shape of the head, hence the purpose of the plaster cast. Lacenaire seemed to support the hypothesis—he was said to have large organs of 'Combativeness', 'Destructiveness', and 'Acquisitiveness', indicating a criminal temperament.

The plaster bust of Lacenaire later played an important role in the wider dissemination of phrenological ideas, particularly concerning criminal character. This example in the Whipple Museum is attributed to the British phrenologist James De Ville (1777–1846). Like many plaster workers in early 19th-century Britain, De Ville was descended from European immigrants, hence his French name. By the 1840s, he owned one of the largest phrenological collections in the country. From his premises on the Strand, De Ville manufactured thousands of busts, including copies of those from Dumoutier's collection in Paris. The plaster bust of Lacenaire therefore represents the beginning of a global story, one in which the circulation of phrenological objects helped construct a universal idea of criminal character.

James Poskett

Bible Album, by Eliza Brightwen, English, 1870s

Wh.6517

THIS PERSONAL SCRAPBOOK, compiled with meticulous care, is replete with illustrations and images of biblical and social scenes, as well as natural observations that include watercolour paintings of natural specimens, clippings of plants, and a pasted-in pair of feathers. It includes dozens of images of women, including Queen Victoria, teachers, mothers, and carers. Her notes and labels, often quotes from biblical scripture, are carefully underlined in colour.

Brightwen was a devoted Christian who believed that the existence of God was demonstrated by the natural world, and who pursued her faith by pursuing a better understanding of the world around her. The scrapbook is a rare manifestation of how scientific pursuit was embedded in wealthy women's lives, cultures, and beliefs during the 19th century. This album was made in the 1870s, during which time Eliza struggled with physical fatigue and her mental health and spent a lot of time at home. Later, following the death of her husband, Eliza's health improved and in her 60s and 70s Eliza began to research and publish her writings on the natural world, even turning their billiard room into a museum at their home in Hertfordshire. She would go on to publish six books before her death in 1906 and was a respected member in a community of natural historians, spreading education about animal preservation and contributing object lessons to schools. A couple of Brightwen's books are in the Whipple Library's special collection, prefaced with letters to other women working in the field and bookplates of previous women owners.

Photographing this object and couriering it to *Making Nature* at the Wellcome Collection in 2016 (where it was passed into Ruth Horry's hands) is a highlight of my time at the Whipple. The way that Brightwen sought to learn from observations, recording, collecting, and experimenting from what was immediately available to her is a humbling and inspiring reminder about appreciating nature and science every day, wherever you are.

Rosanna Evans

Where the birds make their nests: as for the Stork the fir trees are her house. Ps 104.17
If a bird's nest chance to be before thee in the way in any tree or on the ground, thou shalt not take the dam with the young Deut 22.6
And Moses said our cattle also shall go with us, there shall not an Hoof be left behind. Ex X.26.
Then were the Horse hoofs broken by the means of the prancings of the mighty ones Judges 5.22
E.B.
Yea the Sparrow hath found an house & the Swallow a nest for herself where she may lay her young even thine altars O Lord of Hosts My King & my God. Ps 84.3
I watch, and am as a sparrow alone upon the housetop. Ps 102.7.
I watch & am as a Sparrow alone upon the house top. Ps 102.7.
A FEATHERED MESSENGER.
A sparrow lighted chirping on a spray,
Close to my window as I knelt in prayer,
Bowed by a heavy load of anxious care.
The morn was bitter, but the bird was gay,
And seemed by cherry look and chirp to say—
What though the snow conceals my wonted fare,
Nor have I barn or storehouse anywhere,
Yet I trust Heaven even on a winter's day.
That little bird came like a winged text
Fluttering from out God's Word to soothe my breast :
What though my life with wintry cares be vext,
On a kind Father's watchful love I rest.
He meets this moment's need, I leave the next,
And, always trusting, shall be always blest !
Are not two Sparrows sold for a farthing? & one of them shall not fall on the ground without your Father. Matt 10.29.
Fear ye not therefore, ye are of more value than many Sparrows. Matt 10.31.

Peter said Silver & Gold have I none but such as I have give I thee Act. 3.6
Prov 17.9
Eliza Brightwen
Behold I have created the Smith that bloweth the coals in the fire and that bringeth forth an instrument for his work..
Smith.
The Smith with the tongs both worketh in the coals & fashioneth it with hammers and worketh it with the strength of his arms.
HEAR MY PRAYER O LORD
I WILL HEAR THEIR CRY
Exod XXII. 23
And when the chief Shepherd shall appear, ye shall receive a Crown of glory that fadeth not away. 1 Pet V. 4.
"Praying always with all prayer and supplication in the Spirit."—Eph. vi. 18.
Neither days, nor hours, nor seasons, did ever come amiss to faithful prayer. Short passes, quick ejections, concise forms and remembrances, holy breathings, prayer-like little posies, may be sent forth without number on every occasion, and God will note them in His book. To all that have a desire to walk with God, prayer is the key to open the day, and the bolt to shut in the night. The customary devotion of prayer twice a day is as the falling of the early and the latter dew; but if you will increase and flourish in the works of grace, empty the great clouds sometimes, and let them fall into a full shower of prayer; choose out the season in your own discretion, when prayer shall overflow like Jordan in the time of harvest.
—Jeremy Taylor, 1630.
Be thou faithful unto death & I will give thee a Crown of life. Rev 2.10.
STEADFAST IN LIGHT OR SHADOW.
Prayer is the simplest form of Speech, that Infant Lips can try.
A Mother's Influence.

Papier-mâché and painted wood didactic model of a horse fetlock, by Auzoux, French, *c.* 1881

Wh.6544

Being a horse person you can probably imagine my delight when the Museum acquired a model of a horse's hoof and fetlock, made by Dr Auzoux in 1881. Being able to see the horse's hoof and lower leg in this level of detail is a rare treat. The saying 'No hoof, no horse' goes back to the mid-18th century and is still relevant today. A horse is a big animal, weighing around half a tonne, and standing on four tiny hooves, the quality of which is affected by many factors including conformation, genetics, diet, environment, and treatment by the farrier. A horse's ability to work is dependent on it having good feet and even minor changes or injuries to the hoof can cause a great deal of pain and affect a horse's usefulness.

Any horse person will tell you that hoof problems can be devastating and that once they occur there is often very little that can be done to save the horse. Unlike most soft tissue injuries, where you can see swellings, cuts and bruises, feel heat from strained muscles and quickly establish the cause and treat it appropriately, the foot of a horse is much more problematic because you can't see or feel what is going on due to everything being encased in a hard hoof wall. Even seasoned veterinary professionals, when they go to treat a horse with a hoof problem, will start off by probing around the horse's foot hoping that an abscess is causing the problem and that releasing the pressure will solve it – if only it were that simple!

While I expected the human anatomical models to be correct, knowing a bit more about horse anatomy, I did not have the same expectations of Auzoux's model of the hoof and fetlock, so I was truly amazed at what I saw when it was opened up. This model shows in intricate detail the precise anatomy of the hoof enabling it to be examined as closely and clearly as you would see on a dissection, an MRI scan or an X-ray.

It's impossible to say when veterinary medicine first began, presumably people have been treating their animals for illnesses and injuries for as long as they have been sharing their lives with us. However, in Europe, formal veterinary medical training was not established until the late 1700s and one hundred years later Dr Auzoux's model would have been a very effective tool to learn the anatomy of a horse's lower leg and hoof. Even in 2021, horse people like me normally have to learn the anatomy of the hoof from diagrams, which are typically nowhere near as sophisticated as Auzoux's model. What makes the hoof model so special for me is that it is as effective for learning today as it was nearly 150 years ago when it was made.

I'd like to conclude by wishing Liba a very happy and well deserved retirement. I believe she must be the longest serving Director of the Whipple Museum, her tenure covering a 27 year period from 1995–2022. During her time the Museum has been transformed into a vibrant and exciting collection.

Tamara Hug

Plaster models of chicken heads, by Reginald Punnett, English, early 1930s

Wh.6547

After the pea plant, but before the fruit fly, there was, for a brief time, the chicken. In early 20th century Cambridge, when these magnificent models were created, researchers studied the Mendelian laws of heredity by conducting 'backyard' breeding experiments and tracking the inheritance of observable traits over generations. Reginald Punnett, Alfred Balfour Professor of Genetics and likely creator of the heads, bred up to a thousand chicks per year for almost three decades: in 1923 he confessed that 'the hen has seldom been out of my thoughts.'

These eleven painted plaster chicken head models are beautifully detailed and incredibly lifelike, suggesting that they were meant to be observed from up close, perhaps even handled and compared with one another by Punnett's students. But the heads weren't just a novelty: like Ziegler's wax embryo models (see the entry for Wh.6388–98 in this volume), they were likely meant to teach students how to observe specimens like a practising scientist. Research into Punnett's experimental notebooks has shown that quickly and precisely identifying minute differences in particular traits like comb type or plumage colour was the very foundation of experimental practice in early genetics. With these models, Punnett was able to bring the backyard to the lecture theatre, and better inculcate in his students the phenotypic literacy they would need to succeed in genetics.

Matthew Green

Pre-production model of 'The Oxford Astrolabe', by Charles F. Jenkin, English, 1925

Wh.6578

The Whipple Museum holds three examples of one of the earliest modern astrolabes. Its design was based on the collection of astrolabes of Lewis Evans and published in the year that Evans' collection was opened to the public in Oxford in 1925. One of these three, albeit incomplete since it lacks the alidade, is of especial interest as not carrying the inscription of the maker by whom the instrument was commercialized, W. Watson & Sons. Rather, it is inscribed 'The Oxford Astrolabe. Designed after the Persian, Moorish and European Instruments in the Old Ashmolean Museum, Oxford. Hipparchus inv. BC 150 Jenkin del. AD 1925'. Its dimensions, 29.5cm x 23cm, also differ slightly from those of the Whipple's two Watson examples. It may represent an earlier, pre-production, state.

The instrument's provenance is notable, beginning with Derek J. de Solla Price, an early assistant to A. Rupert Hall in the Whipple Museum in the 1950s, thence from his estate to Alain Brieux, poet, antiquarian bookseller and co-author (with Francis Maddison), of 'Répertoire des Astrolabistes et de Leurs Oeuvres: Islam', thence from his widow, Dominique Brieux, to Anthony Turner who presented it to the Whipple Museum in September 2014.

The astrolabe, made in aluminium, brass and celluloid, was designed by Charles Frewen Jenkin (1865–1940), the first professor of Engineering Science at Oxford, and made by him in his laboratory. R. T. Gunther, creator and first curator of the Lewis Evans collection, wrote in his second annual report (1925), 'Of outstanding importance has been the construction of the Oxford astrolabe ... [Jenkin's] instruments … have been made for the latitudes of Oxford and Edinburgh. He has thereby provided schools with a new educational instrument of great value'.* To accompany

* Albert E. Gunther, *Robert T. Gunther: A Pioneer in the History of Science 1869–1940*, Early

the instrument Jenkin wrote a short manual, *The Astrolabe: Its Construction and Use*, and four years later he also produced 'an astrolabe slide with rotating rete for lantern demonstration' that was also made and marketed by Watson & Sons.†

Anthony Turner

Science in Oxford, vol. 15 (Oxford: Oxford University Press, 1967), p. 376.
† Jenkin's astrolabe is further described in G. N. Pingriff, 'The Astrolabe', *Schools Science Review*, June 1927; and Robert T. Gunther, *The Astrolabes of the World*, vol. 2 (Oxford: Oxford University Press, 1932), pp. 522–23. On the lantern astrolabe, see Gunther, *Robert T. Gunther*, *op. cit.*, p. 408.

Didactic anatomical model of a frog, English, mid-20th century

Wh.6599

Standing at 52cm high and 107cm wide, this large three-dimensional model of the anatomy of a frog was used for university teaching by Whipple neighbours: the Zoology Department on the New Museums Site. Originally situated on a large square mirror, one can imagine students looking, at distance, down from the lecture theatre seating and seeing into the body of the frog. The frog's plaster bones are cream, but the sixty-four numbered muscles, made in wax, are in a variety of bright colours for ease of reference in teaching. Accompanying keys would enable teachers and students to identify anatomical features of the frog. Frogs are often used by scientists and in teaching as model organisms, providing insight into more general biological processes.

Mr. Froggy, as he is affectionately called by staff, was in poor condition when he arrived at the Whipple Museum and was carefully conserved to improve his structure. Following research into the frogs in our collection carried out in 2016, it was determined that Mr. Froggy may not, in fact, be a Mister. It is impossible to discern Mr. Froggy's gender: he is a composite of multiple frogs and thus the determining features are not distinctly male or female.

Mr. Froggy currently sits in the Learning Gallery, looking out through the glass cases into the Main Gallery – and, given the difficulty of getting him up there, I think he will stay there for a good while. As Learning Co-ordinator, I was frequently asked by children whether Mr. Froggy was a fossil of a prehistoric frog creature. Thankfully he is much too charming for that. A personal highlight (or should I say baptism of fire?) was participating in a frog-themed research project, disseminating research by Liba and Henry Schmidt in public engagement with families throughout the summer of 2016. Following a competition that formed a part of these activities, a careful judging panel of Whipple Museum staff members selected first names for Mr. Froggy and Emile Deyrolle's anatomical model of a frog dated to the second half of the 19th century (this one clearly a female due to the presence of spawn on the model): Paddy and Lily.

Rosanna Evans


4
24
25

The Charles Elcock archive of microscope slides, preparatory tools and related materials, Irish, 1872–1910

Wh.6601

Charles Elcock (1834–1910) was a naturalist, museum curator, and professional microscope slide maker who worked in Belfast and moved from science as a hobby to science as a commercially successful profession during his lifetime. The Museum purchased the slides and equipment which were still in his possession at his death when they came into the hands of a private dealer in or before 2015. The collection is a fascinating snapshot into the life of a working microscopist, including everything from beautifully prepared slides of unique organisms to spare pen nibs and even a ball of string. It is a perfect example of the way in which, as Liba Taub puts it, 'by reengaging with instruments in museums historians of science can offer fresh perspectives' on the history of science and scientists.[*]

The collection has captured the attention of many students and researchers at the Museum and has led to research including an MPhil essay on 'Charles Elcock and the Postal Microscopical Society: A 19th-Century Scientific Community' which is available as a case study in the Whipple Museum. It has also been the inspiration for a recent museum remix project which concentrates on Elcock's specialist subject of foraminifera, calling for more 'pink sand science' and giving another fresh perspective on the untold stories of scientists and the objects they use.[†]

Once he had established himself and begun to list his profession as 'microscopist', Charles Elcock served as curator at the free public library in Belfast, combining active engagement in his field with a commitment to preserving historical objects and keeping them available for scholars

* Liba Taub, 'Introduction: Reengaging with Instruments', *Isis* 102 (2011), pp. 689–96.
† Laura Grace Simpkins, 'Dive into the world of tiny marine creatures, Foraminifera', University of Cambridge, *Museum Remix: Unheard*, 2021: https://www.museums.cam.ac.uk/magic/foraminifera.

and the general public. The preservation of the Elcock collection at the Whipple Museum is an excellent example of the importance of material objects in telling scientific stories which might otherwise be lost. Because Elcock only published research papers sporadically and in obscure journals, making many of his observations in private letters, his career might well have been forgotten without the work of Liba and the Whipple team.

Now, as well as being of significant interest to scholars in the department, the collection takes pride of place in our learning sessions. It is used to highlight three very important aspects of the collection and Museum, which are also key facets of Liba's contribution to it: the fact that you don't have to be rich and famous to 'do science'; the importance of scientific communities and collaboration; and the key role of objects in learning about the history of science.

Alison Giles

‘Seed Source Indicator’, set of 25 microscope slides, [English], *c.* 1900

Wh.6624

This modest seed herbarium presents seeds of one hundred plant species originating across Europe, the Middle East, and the Americas, labelled and arranged in a commercially manufactured microscope slide box. Little is known about it. There is no place or date of creation and no record of its ownership. Even its uses were initially obscure. The handwritten outer label, ‘Origin of Seeds Source Indicators’, and contents list within, which provides information about each sample’s status as something called a ‘source indicator’ via the listing of miscellaneous forage crops, are hardly scrutable, even to historians of agricultural science.

The herbarium is an unusual specimen. Like other seed herbaria, such as those kept by individual botanical researchers or institutions such as botanical gardens and arboreta as reference tools for identification and classification, this small collection enabled its handler to identify the species or genus of a seed via its visible characteristics. The ultimate aim of this initial identification, however, was not to learn more about the seed being compared to the herbarium specimens, as one might typically expect. Instead, it was to correctly categorise still other seeds, ones with potentially far more value.

The Whipple’s herbarium was not an all-purpose reference tool but one designed to facilitate a specific agricultural task: it enabled its user to deploy the unwanted weed seeds inherent in commercial seed stocks as much-needed evidence of the geographic origins of those stocks – that is, as ‘source indicators’. To that end, it contains only the seeds of weeds of circumscribed geographical distribution commonly found among forage or fodder crops. Seed testing stations adopted the use of these weed seeds as indicators of provenance in the 19th century, when the increasing internationalisation of the seed market raised new concerns about whether the geographic origins of seeds were truthfully advertised. This was considered essential to determining whether they would grow well in the sometimes far-flung locations in which they were now sold.

The mobilisation of agricultural pests (weeds) in the service of agricultural improvement (accurately labelled seed) was short lived, not least because weed seeds proved just as mobile as the crops they travelled with. Once geographically localised weeds naturalised in new places, they could no longer serve as reliable 'source indicators', making seed herbaria like the Whipple Museum's 'Origins of Seeds Source Indicator' distinctly less useful in the regulation of agricultural trade.

Helen Anne Curry

Fossil collection, displayed in a book-shaped box, by Václav Frič, Austro-Hungarian, *c.* 1870

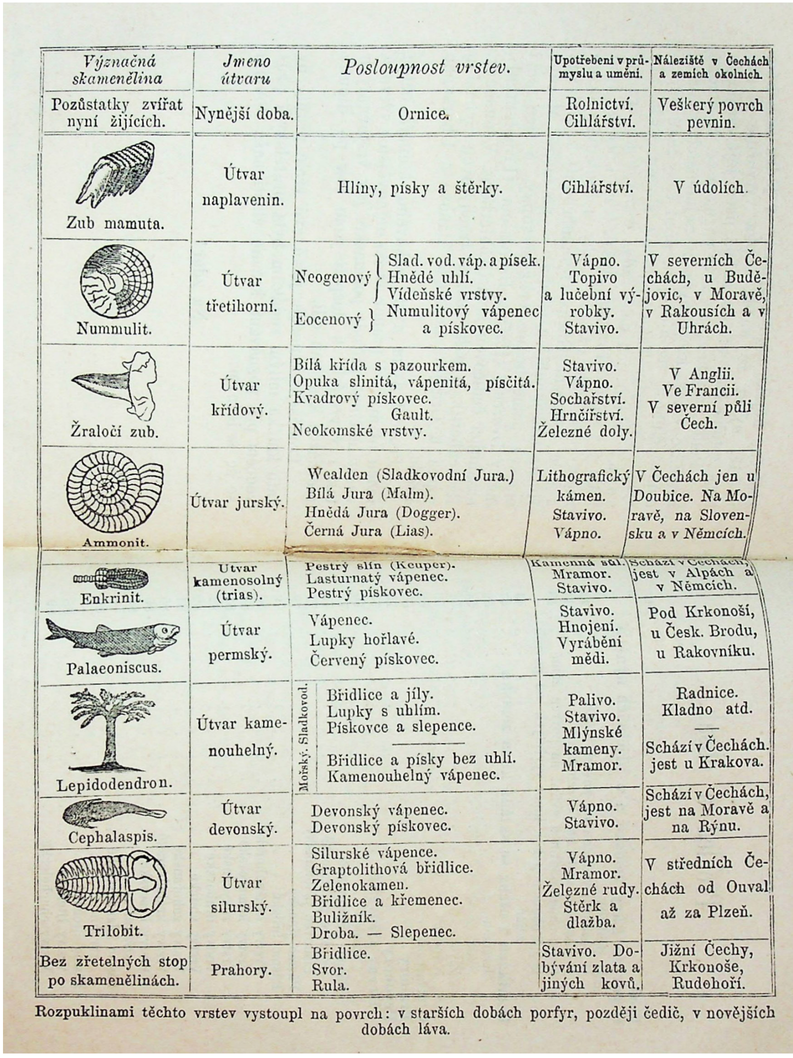
Wh.6647

What is a scientific instrument? This is a question that Liba Taub has posed on several occasions, and this is a question that is especially relevant for Václav Frič's *Vzory vrstev zemských* (*Types of Geological Strata*), a small collection of fossils and rocks that is housed in a box that looks like a book from the outside.[*] Is this a book? Is this a collection? Or is this an educational instrument?

The *Vzory vrstev zemských* contains two parts inside the box. On the left, it contains a table that shows, for each geological time period, the main fossil finds, the representative rock strata, their uses in crafts and industry, as well as their location in Czechia and the neighbouring regions. On the right, the box contains a sample of rocks and fossils of each period together with two rows of sedimentary and igneous rocks at the bottom.

* Liba Taub, 'What is a Scientific Instrument, Now?', *Journal of the History of Collections* 31 (2019), pp. 453–467.

Commercial and academic endeavours in natural history were intimately connected in the 19th century, and Frič's work was no exception.[†] Václav Frič was one of the most prominent instrument dealers of the second half of the 19th century, who also served as an agent of the renowned glassblower Blaschka family.[‡] His brother Antonín Frič was, in turn, a prominent curator at the National Museum in Prague, who published extensively on a variety of topics in natural history and palaeontology. The fossil box of *Vzory vrstev zemských* is a testament to the close ties between commerce and science, as represented by the two brothers. A variant of the printed sheet on the right, with slight changes to the layout, is also present at the end of Antonín Frič's *Malá Geologie*, a highly popular and brief educational textbook of geology that was first published in 1869 and was still in print in the early 20th century.[§] Arguably, Václav Frič's box of fossils could be considered a three-dimensional educational enhancement tool and companion volume to the *Malá Geologie*.



Význačná skamenělina	*Jmeno útvaru*	*Posloupnost vrstev.*	Upotřebeni v průmyslu a umění.	Naleziště v Čechách a zemích okolních.
Pozůstatky zvířat nyní žijících.	Nynější doba.	Ornice.	Rolnictví. Cihlářství.	Veškerý povrch pevnin.
Zub mamuta.	Útvar naplavenin.	Hlíny, písky a štěrky.	Cihlářství.	V údolích.
Nummulit.	Útvar třetihorní.	Neogenový { Slad. vod. váp. a písek. Hnědé uhlí. Vídeňské vrstvy. Eocenový { Numulitový vápenec a pískovec.	Vápno. Topivo a lučební výrobky. Stavivo.	V severních Čechách, u Budějovic, v Moravě, v Rakousích a v Uhrách.
Žraločí zub.	Útvar křídový.	Bílá křída s pazourkem. Opuka slinitá, vápenitá, písčitá. Kvadrový pískovec. Gault. Neokomské vrstvy.	Stavivo. Vápno. Sochařství. Hrnčířství. Železné doly.	V Anglii. Ve Francii. V severní půli Čech.
Ammonit.	Útvar jurský.	Wealden (Sladkovodní Jura.) Bílá Jura (Malm). Hnědá Jura (Dogger). Černá Jura (Lias).	Lithografický kámen. Stavivo. Vápno.	V Čechách jen u Doubice. Na Moravě, na Slovensku a v Němcích.
Enkrinit.	Útvar kamenosolný (trias).	Pestrý slín (Keuper). Lasturnatý vápenec. Pestrý pískovec.	Kamenná sůl. Mramor. Stavivo.	Schází v Čechách, jest v Alpách a v Němcích.
Palaeoniscus.	Útvar permský.	Vápenec. Lupky hořlavé. Červený pískovec.	Stavivo. Hnojení. Vyrábění mědi.	Pod Krkonoší, u Česk. Brodu, u Rakovníku.
Lepidodendron.	Útvar kamenouhelný.	Sladkovod. Břidlice a jíly. Lupky s uhlím. Pískovce a slepence. Mořský. Břidlice a písky bez uhlí. Kamenouhelný vápenec.	Palivo. Stavivo. Mlýnské kameny. Mramor.	Radnice. Kladno atd. — Schází v Čechách. jest u Krakova.
Cephalaspis.	Útvar devonský.	Devonský vápenec. Devonský pískovec.	Vápno. Stavivo.	Schází v Čechách, jest na Moravě a na Rýnu.
Trilobit.	Útvar silurský.	Silurské vápence. Graptolithová břidlice. Zelenokamen. Břidlice a křemenec. Buližník. Droba. — Slepenec.	Vápno. Mramor. Železné rudy. Štěrk a dlažba.	V středních Čechách od Ouval až za Plzeň.
Bez zřetelných stop po skamenělinách.	Prahory.	Břidlice. Svor. Rula.	Stavivo. Dobývání zlata a jiných kovů.	Jižní Čechy, Krkonoše, Rudohoří.

Rozpuklinami těchto vrstev vystoupl na povrch: v starších dobách porfyr, později čedič, v novějších dobách láva.

Václav Frič was a dealer of international importance, regularly

† See Dániel Margócsy, 'Malinowski and Malacology: Global Value Systems and the Issue of Duplicates', *British Journal for the History of Science*, forthcoming 2022.

‡ Henri Reiling, 'Glass Models of Soft Bodies Animals: The Relation between Blaschka, Frič and the National Museum', *Časopis Národního muzea, Řada přírodovědná* 171 (2002), pp. 131–75.

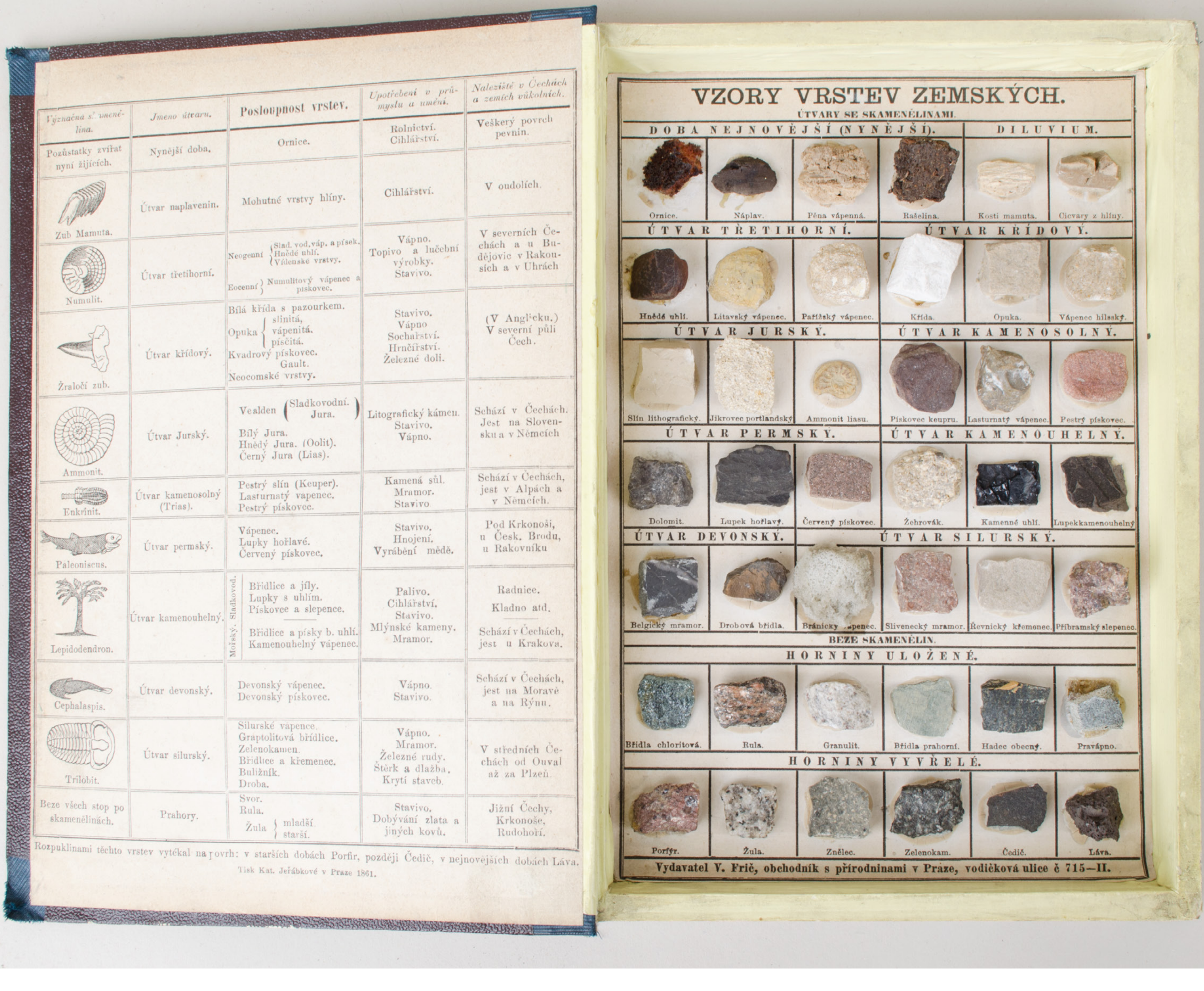
§ The first edition is Antonín Frič, *O vrstvách kůry zemské a skamenělých tvorech v nich obsažených* (Prague: Spolek pro vydávání laciných knih českých, 1869), Fig. 1 located after p. 227. I used the 1875 edition, which bears the new title.

exhibiting at world fairs.¶ His specimens, models, and instruments can be found today in museums across the world, including several objects at the Whipple Museum.** Yet his *Vzory vrstev zemských* was published in Czech, revealing the growing national interest in natural history in the period. His other brother, Josef Václav Frič, was a promoter of Slavic national revival and a revolutionary of 1848, who spent part of the 1850s in exile in London, where Václav visited him for an extended period of time.†† Antonín Frič contributed to this mission of national revival by publishing several volumes, in German and in Czech, on the fishes, palaeontology and geology of Czech lands.‡‡ To be a patriot, one needed to know Czech nature as well as Czech culture. This is probably why the *Vzory vrstev zemských* contained a column with information on the location of various geological strata around Czechia.

At the dawn of the 21st century, as paper books are increasingly obsolete, Frič's education tool serves as an important reminder that, for long centuries, the physical format of the book was a key tool for the organisation of knowledge. The book's rectangular shape and size did not only influence how people read, but also how they collected and ordered the natural world around them.

Dániel Margócsy

¶ Henri Reiling and Taťjána Spunarová, 'Václav Frič (1839–1916) and his Influence on Collecting Natural History', *Journal of the History of Collections* 17 (2005), pp. 23–43.
** Václav Frič. Set of six cardboard crystal structure models, Wh.6263: https://collections.whipplemuseum.cam.ac.uk/objects/14979; Václav Frič, Fresnel's mirror for interference demonstration, Wh.6493: https://collections.whipplemuseum.cam.ac.uk/objects/15204; Václav Frič, Seven plaster models of single-celled organisms, Wh.6530: https://collections.whipplemuseum.cam.ac.uk/objects/15239.
†† On Josef Václav Frič's revolutionary activities, see Josef Václav Frič, *Paměti* (Prague: Jakub Malý, 1885–87). I used the Hungarian translation, Josef Václav Frič, *Emlékeim* (Budapest: Művelt Nép, 1951).
‡‡ See, for instance, Antonín Frič, *České ryby* (Prague: Antonín Renn, 1859).



Význačná skameněliná.	Jmeno útvaru.	Posloupnost vrstev.	Upotřebení v průmyslu a umění.	Naleziště v Čechách a zemích vůkolních.
Pozůstatky zvířat nyní žijících.	Nynější doba.	Ornice.	Rolnictví. Cihlářství.	Veškerý povrch pevnin.
Zub Mamuta.	Útvar naplavenin.	Mohutné vrstvy hlíny.	Cihlářství.	V oudolích.
Numulit.	Útvar třetihorní.	Neogenní { Slad. vod. váp. a písek. Hnědé uhlí. Vídenské vrstvy. Eocenní { Numulitový vápenec a pískovec.	Vápno. Topivo a lučební výrobky. Stavivo.	V severních Čechách a u Budějovic v Rakousích a v Uhrách
Žraločí zub.	Útvar křídový.	Bílá křída s pazourkem. Opuka { slinitá, vápenitá. písčitá. Kvadrový pískovec. Gault. Neocomské vrstvy.	Stavivo. Vápno Sochařství. Hrnčířství. Železné doli.	(V Anglicku.) V severní půli Čech.
Ammonit.	Útvar Jurský.	Vealden (Sladkovodní. Jura.) Bílý Jura. Hnědý Jura. (Oolit). Černý Jura (Lias).	Litografický kámen. Stavivo. Vápno.	Schází v Čechách. Jest na Slovensku a v Němcích
Enkrinit.	Útvar kamenosolný (Trias).	Pestrý slín (Keuper). Lasturnatý vapenec. Pestrý pískovec.	Kamená sůl. Mramor. Stavivo	Schází v Čechách, jest v Alpách a v Němcích.
Paleoniscus.	Útvar permský.	Vápenec. Lupky hořlavé. Červený pískovec.	Stavivo. Hnojení. Vyrábění mědě.	Pod Krkonoši, u Česk. Brodu, u Rakovníku
Lepidodendron.	Útvar kamenouhelný.	Sladkovod.: Břidlice a jíly. Lupky s uhlím. Pískovce a slepence. Mořský.: Břidlice a písky b. uhlí. Kamenouhelný vápenec.	Palivo. Cihlářství. Stavivo. Mlýnské kameny. Mramor.	Radnice. Kladno atd. Schází v Čechách, jest u Krakova.
Cephalaspis.	Útvar devonský.	Devonský vápenec. Devonský pískovec.	Vápno. Stavivo.	Schází v Čechách, jest na Moravě a na Rýnu.
Trilobit.	Útvar silurský.	Silurské vápence. Graptolitová břidlice. Zelenokamen. Břidlice a křemenec. Buližník. Droba.	Vápno. Mramor. Železné rudy. Štěrk a dlažba. Krytí staveb.	V středních Čechách od Ouval až za Plzeň.
Beze všech stop po skameněliňách.	Prahory.	Svor. Rula. Žula { mladší. starší.	Stavivo. Dobývání zlata a jiných kovů.	Jižní Čechy, Krkonoše, Rudohoří.

Rozpuklinami těchto vrstev vytékal na povrh: v starších dobách Porfir, později Čedič, v nejnovějších dobách Láva.

Tisk Kat. Jeřábkové v Praze 1861.

Compendium with tide computer and calendar disks, attributed to Charles Whitwell, [English], late 16th century

Wh.6653

This pocket-sized instrument offers us a tiny window into the complex world of late-Elizabethan navigation, astronomy, and instrument makers. It consists of two brass discs, sandwiched together with a revolving centre. Each side is stacked with additional rotating discs ('volvelles') that can be adjusted for various calculations, similar to a circular slide rule.

For the Tudor seafarer, this gadget was a helpful aid in gauging the time of high tide and when best to enter port in deep waters. Due to the irregular shape of the coastline, each harbour had its own average measure of the time lapse ('establishment of port') between the Moon's transit across the local meridian and the next high tide at Full and New Moon. To help them remember and visualise these values, mariners used the familiar shape of the 32-point compass rose to assign 45-minute intervals to each point, with lunar noon at south. Hence Bristol's establishment of port could be described as 'East-by-South' [5h15m delay], while Dartmouth was 'West-South-West' [4h30m delay]. With the Moon rising 48 minutes later each day, the mariner could adjust these volvelles to the relevant compass point and lunar phase to calculate the time of high water for their chosen port on any day of the month.

The other side features a series of scales that enable the user to convert between the civil months of the year and the zodiac calendar as a measure of the Sun's progress against the background stars. Although several continental countries had switched to the Gregorian calendar in 1582, English people were still suspicious of this seemingly Catholic calendar and resolved to continue with the Julian system, hence we find the Vernal Equinox on these scales on 10 March, rather than 21 March. The uppermost volvelle has a small aperture that rotates to reveal the changing shape and phase of the Moon underneath. In the central section we can see the faded outline of an aspectarium, an astrological diagram

based on the notion that certain angles between the Sun, Moon and planets could portend good or bad times ahead.

Although the instrument is unsigned, we can be fairly confident that it was made by Charles Whitwell (*fl.* 1582–1611) from the distinctive stylistic traits on specific letters and numerals. He was part of the second generation of London scientific instrument makers who initially trained as engravers and later developed their creative and mathematical flair in this emerging trade. We know very little about Whitwell himself, apart from an address near the Strand, an association with eight apprentices, and a mention of his wife Elizabeth and their children. A corpus of around twenty surviving instruments, scattered across various museum collections, reveals Whitwell's mathematical prowess and versality in creating instruments for astronomy, surveying, navigation, dialling, and technical drawing. We may never know whether these volvelles were intended as a standalone instrument, or as part of a more complex astronomical compendium, but they still provide us with a rare opportunity to learn more about this elusive Elizabethan craftsman.

Louise Devoy

Chemistry set, no. 2, by A. C. Gilbert Company, USA, *c.* 1936

Wh.6664

THIS INTERWAR CHEMISTRY SET is one of the millions of scientific toys sold by American company Gilbert across the 20th century that are now eBay treasures. Founded in Connecticut in 1909 by Olympic champion pole-vaulter, magician, and graduate of Yale medical school, Alfred Carlton Gilbert, the toymaker was one of the two predominant American manufacturers of mass-produced chemistry sets (the other was the Porter Chemical Company, maker of the 'Chemcraft' set) from around World War One up to their 1950s heyday. Gilbert's extensive product line, which beyond the chemistry set included glassblowing, mineralogy, electrical kits, and the still more popular 'Erector' construction set among many others, appealed to parents of the expanding middle class, encouraged by progressive educators and manufacturers to view scientific toys as vehicles for sharpening childhood curiosity in the laws of nature, but more especially the emerging industries which underpinned American modernity and prosperity. Chemistry sets, in particular, found their market amid the growth of and enthusiasm for the chemical industry, promoted as combining the appeal of pure science and the potential for social good with the possibilities of industrial exploitation and profit. Gilbert sets were marketed as 'career toys', that channelled childhood consumptive desires into productive hobbies that might enhance their young users' professional prospects, a strategy that was especially important in the 1930s, as Depression-era parents worried that their own diminished material circumstances might stunt their children's future success.*

The 'chemistry set no. 2' was a generally affordable, entry-level 'junior laboratory' accessible to relative novices. Gilbert's trademark blue metal cabinet contained 26 pieces of apparatus and chemicals, compared to the 100 plus in more advanced (and expensive) sets aimed at older 'master chemists'. Designed to stand upright to evoke an enclosed laboratory, even the

* Salim Al-Gailani, 'Magic, Science and Masculinity: Marketing Toy Chemistry Sets', *Studies in History and Philosophy of Science Part A* 40 (2009), 372–81.

more basic sets claimed an authentic connection to the world of adult science, advertising the involvement of actual scientists in the construction of the toys and content of the instruction manuals. This also offered parents the assurance of expertise and safety, although the set contained materials that regulators would, by around 1970, recast as too hazardous for children. This set contains the ingredients for gunpowder, and the manual explains how to make it.

Salim Al-Gailani

Pocket sundial with Chinese characters, by Samuel Porter, English, *c.* 1825

Wh.6670

Having a tiny sundial mounted on top of a rotating compass card, this clever dial orients itself to magnetic north without any bother of its owner. Floating sundials may have originated in France but became fashionable in Bavaria in the late 18th century. They were popularized in England by Samuel Porter of London, who copyrighted his original design on February 16, 1824 at Stationers' Hall. He must have quickly recognized a market in China, because on March 17, 1825 – just a year later – Porter protected a new design for export. The Whipple Museum's example is the latter.

For the export version, Porter replaced the common hours marked in Roman numerals on his English sundial with the Chinese double hours. Named after zodiacal animals, they run from the second hour of rabbit (*mao*) through the double hours of dragon (*chen*), snake (*si*), horse (*wu*), sheep (*wei*), and monkey (*shen*), to the initial hour of rooster (*you*) per the conventional order. The noon double hour, horse (*wu*), is centered on and aligned with the gnomon and north point, and in Western terms covers the period of 11am to 1pm. Every double hour is divided into eight units, each equivalent to fifteen minutes.

Surrounding the hour scale are eight points of the compass in the modern style rather than the traditional feng shui system. Cardinal directions are indicated with Chinese characters – *bei* (north), *nan* (south), *dong* (east), *xi* (west) – and the ordinals by pairs of these.

Porter also altered the decoration of his sundial. His English market dials featured the winged figure of Father Time holding a sand glass and scythe, a symbol of time's fleeting and lethal nature. He was placed in the southern gap of the hour scale, his feet touching the toe of the gnomon. Unexpectedly encircling him and the hour scale was an ouroboros (a snake biting its own tail), a symbol of cyclical time without end. The English sundial thus presents a mixed message. For the export dial, Porter got rid of Father Time and the ouroboros. In the gap, he positioned a large bat, its wings wide open and head towards the south. Its auspicious message to a Chinese owner would have been clear: good fortune.

We would expect the sundial to be for about 23°N, the latitude of Canton (today Guangzhou), the principal city through which the English had traded since 1760, but it is not. Reverse engineering the hour lines reveals that the sundial was designed for about 32°N, which is that of Nanking and a bit north of Shanghai. But before the end of the First Opium War (1839–42) and the Treaty of Nanking, Shanghai was a fishing village, not the great Treaty Port and open market it would become.

For whom was the sundial designed in 1825, and could it have been made much later than its patent date? With hindsight of the social and economic consequences of the First Opium War, we might reconsider whether the bat on this dial was such an auspicious portent after all.

Sara J. Schechner

Pocket sundial with Chinese characters, by Samuel Porter, English, *c.* 1825

Wh.6670

This magnetic pocket sundial is unassuming, yet intriguing (image on previous page). Made by Samuel Porter, it bears the date 17 March 1825, and was entered at Stationers' Hall the following day as 'Porter's Magnetic Sun Dial on the Floating Compass Card in Chinese Characters.'* Porter was a London instrument maker and is thought to have been the first English retailer of the magnetic dial, which became popular in the early 19th century.†

Like Porter's other dials, here a gnomon is affixed to the top of the printed compass card, and a magnetic needle is attached beneath; yet the imagined user is distinctive. An illustration of a bat (commonly associated with longevity in China) is placed before the gnomon, replacing an image of Father Time that appears on the dials Porter made for the English market.‡ Along the outer ring, the eight cardinal and intercardinal directions are given in Chinese characters. The inner ring provides a means of telling time, labelled with seven dizhi 地支 or earthly branches which indicate Chinese double-hours between 6am and 6pm. The best estimate, using the angles of the dial lines and considering the moderately shallow angle of the gnomon, is that the sundial was made to work at a latitude of about 32° N, which broadly corresponds to central China and most possibly the city of Nanjing, an old imperial capital and an administrative centre for the wealthy and powerful lower Yangzi region.

Although the dial was apparently made for China, it is missing some of the notation that would have made it useful there, although it is unclear

* Robin Myers (ed.), *Records of the Worshipful Company of Stationers, 1554–1920* (London: Stationers' Company, 1985), microfilm reel 13, p. 532.
† Gerard Turner, *Scientific Instruments, 1500–1900: An Introduction* (London: Philip Wilson 1998), p. 19. Two more of Porter's magnetic dials may be found at Royal Museums Greenwich: inv. nos. AST0242 and AST0241.
‡ Mike Cowham, 'Magnetic Compass Dials', *Bulletin of the Scientific Instrument Society* 149 (2021), pp. 26–28, on p. 26, figs. 4 and 5.

whether Porter would have understood this, or how he collaborated with Chinese sources to produce this object. Pocket sundials and compasses had long been produced domestically; the Whipple holds an example of one such instrument, a pseudo-equinoctial dial made in 19th-century Huizhou and bearing the signature of Fang Xiushui (Wh.3188). Chinese mariners began to use dry compass-cards in the 16th century, having acquired them from Japan.[§] Yet Chinese compasses did not necessarily use the modern directional indicators north 北, south 南, east 東, and west 西 which appear on Wh.6670; navigators generally used a system of twenty-four cardinal directions integrating *dizhi* with *tiangan* 天干 or heavenly stems.[¶]

What use might such an instrument then find in China? One possible explanation is that it was a novelty item manufactured for private trade between Great Britain and China outside the formal Canton system.[**] For instance, in 1825, two cases of 'mathematical and optical instruments' were exported to China from Great Britain at a value of £400.[††] Such items were by the early 19th century predominantly exchanged for Chinese tea. The small scale of this commerce in instruments stands in stark contrast to the large quantities of opium then regularly shipped to China for the same purpose.

Mary Augusta Brazelton

§ Joseph Needham et. al., *Science and Civilisation in China, Vol. 4, Physics and Physical Technology, Part 1: Physics* (Cambridge: Cambridge University Press, 1962), pp. 288–90.

¶ A photograph in Needham, *op. cit.*, provides one example of a mariner's dry-pivoted compass dating to the early Qing dynasty (1644–1911) with the four cardinal directions carved on it, but these are still accompanied by the conventional 24 compass-points (see fig. 337, plate CXVIII). Needham discusses the geomantic origins and significance of the 24 compass-points on pp. 297–98.

** Earl Pritchard, 'Private Trade between England and China in the Eighteenth Century (1680–1833)', *Journal of the Economic and Social History of the Orient* 1 (1957), 108–37, on pp. 125–26.

†† John Macgregor, 'An Account of all Goods Exported to China from Great Britain, &c.', *Commercial Statistics: A Digest of the Productive Resources, Commercial Legislation, Customs Tariffs, of All Nations. Including All British Commercial Treaties with Foreign States*, vol. 5 (London: Whittaker and Co., 1850), p. 37.

‘Henderson Dial’ mining theodolite, by J. T. Letcher, English, late 19th Century

Wh.6711

For anyone interested in surveying instruments, ever the poor relation of astronomy and navigation, one impressive acquisition since 1995 outshines any microscope or astrolabe. This is the uncommon ‘Henderson Dial’ for mine surveying, part of the search for an equivalent of the theodolite but for use underground. As a complex assemblage of parts, housed in two original cases for stowage and carriage, no other qualifying accession so clearly belongs in the shop in *Dombey & Son*, which Dickens stocks with ‘Objects in brass and glass … which none but the initiated … could have ever got back again into their mahogany nests without assistance.’

The challenge and the paradox of surveying underground was that the register of direction relied on the magnetic compass, working in a context where deviation of the local magnetic meridian might be large, varied and unpredictable, and where no corrective sights could be taken from Sun or stars.

James Henderson (1821–1903) from Aberdeen spent a decade surveying in Australia before settling in Truro, Cornwall, in *c.* 1851 as a mining engineer and surveyor. His dial was a development of the more common ‘Lean’ dial, itself a modification of the plain miner’s dial or ‘circumferentor’. All were versions of the surveying compass. In the Lean dial the normal pair of fixed sights, set on north and south extensions beyond the compass box, could be removed and replaced by a vertical semicircle carrying a telescopic sight for altitudes. In addition, the horizontal angle could be read independently of the magnetic needle, so that the instrument could be used above ground as a theodolite.

In the Henderson dial a second pair of plain sights was carried by an alidade that could rotate below the compass. This explains why the Whipple instrument has two pairs of plain sights in addition to Lean’s innovation of a telescopic sight on a semicircle. The idea seems to have been that at a station in an underground survey, the fixed sights would be aligned with the back-object and the moveable sights trained on the fore-object.

Perhaps this was an unnecessary complication, though another explanation of the relative rarity of Henderson's dial is that it was made, it seems exclusively, by J. T. Letcher of Truro, while the Lean dial was carried by much larger manufacturers, such as Stanley and Troughton & Simms. Letcher had more success with his blowpipe analysis kits, awarded a silver medal by the Society of Arts.

The dial is remarkably complete. There are three ball-and-socket mounts with their levelling screws, one being for the dial and the others for a lamp or candle when working underground. Notably the candleholder has two spirit levels, so we may surmise the importance of having a truly vertical candle to view in the dial's slit and window sights from the far end of a traverse line underground. A concluding exercise for the reader is to find the nine screw-fit conical feet for the three tripod stands.

Jim Bennett

Demonstration model of the human middle ear, by H. Sittel, German, *c.* 1868

Wh.6714

In 1868, the German physiologist and physicist Hermann Helmholtz published a detailed description and mechanical analysis of the human ear, reporting that he had constructed a scale model of the three tiny bones that transfer vibrations from the outer eardrum to the inner ear. Such a model 'is very useful, both for demonstration and for quickly clarifying the meaning of the various tissues and links that hold the bones because one can take everything apart and can strengthen or weaken the individual ligaments,' Helmholtz wrote.

Models pop up everywhere in science, offering analogies between things lesser known and better known. Already in the 16th century, European anatomists had named the ear bones the 'hammer', 'anvil', and 'stirrup'. Helmholtz now modeled their linked motions and scaled up their size by twenty-fold to make visible their interaction (measuring only 2 x 3 mm, the stirrup is the smallest bone in the human body). Interestingly, children's model cars scale down the size of the automobile, also by twenty-fold. Such models help us 'see' the world in the scale of our own body.

In 1868, Helmholtz's assistant, an otherwise unknown Herr Sittel, began making and selling copies of the ear model to other physiological laboratories across Europe, including the Whipple version purchased, at some point, by the Free University of Brussels. Judging by the wear and tear visible on the Whipple device, we might guess that generations of medical students in Brussels played with this model as they learned the anatomy of the human auditory system. But did they think that this model, constructed of wood, metal, paper, and leather, was actually 'the ear of Helmholtz', as recorded on the hand-written label attached to its front surface? Are models 'real'?

Richard L. Kremer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Mécanisme des osselets
de l'oreille de
Helmholtz
de Bruxelles.
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Calendarium Naturale Magicum Perpetuum, astrological / cosmological calendar, compiled by John Baptist Grosschedel, published by Johann Theodor de Bry, German, *c.* 1619

Wh.6716

The *Calendarium naturale magicum perpetuum* offers a detailed compendium of the occult philosophy pursued by some European intellectuals in the early 17th century.* Its overall plan is straightforward, a sequence of horizontal sections corresponding to the numbers from one at the top down to twelve. Each section details in lists (in Latin) and images a host of things linked to that number, combining elements one might now identify as religious, philosophical, astrological, alchemical, mystical and natural. Associations of the number four, for example, include the Biblical evangelists, the elements (earth, water, air, fire) and their angelic governors, the powers of the soul, the zodiacal triplicities, the four fundamentals of mathematics (point, line, plane, volume), the Galenic humours, the seasons, and the moral virtues. There is, by contrast, little for the number eleven because of its association with sin.

Three people's names appear on the calendar. At bottom right is a spurious attribution to the Danish astronomer Tycho Brahe (1546–1601) and the date 1582, presumably to confer authority on the work. Above this the engraver and publisher Johann Theodor de Bry (1561–1623) is identified. De Bry's printing firm notably published many emblem books and alchemical and mystical texts. At bottom left is the name of Johann Baptista Großchedel von Aicha (1577–1630s), a German nobleman with alchemical and occult interests, whose role as compiler has been confirmed by the identification of British Library MS Harley 3420, dated 1614, as the manuscript source for the *Calendarium*.

* Carlos Gilly, 'The Rediscovery of the Original of Großchedel's Calendarium Naturale Magicum Perpetuum', in Carlos Gilly and Cis van Heertum (eds), *Magia, Alchimia, Scienza Dal '400 al '700. L'influsso di Ermete Trismegisto / Magic, Alchemy and Science 15th-18th Centuries. The Influence of Hermes Trismegistus*, 2 vols. (Florence: Centro Di/Edifimi Srl., 2002), 1, pp. 310–17; Adam McLean, *The Magical Calendar: A Synthesis of Magical Symbolism from the 17th-Century Renaissance of Medieval Occultism* (Grand Rapids: Phanes Press, 1994).

The print's content is a synthesis of the work of compilers and thinkers in vogue in a period of renewed interest in occult philosophy and the cataloguing of magical qualities. One of the principal sources is *De occulta philosophia* (*On Occult Philosophy*) by Heinrich Cornelius Agrippa von Nettesheim (1465–1535), which was circulating in manuscript by 1510 and first printed in 1533, with many further editions following. Agrippa's popular and influential work describes 'natural magic', intended as a religiously acceptable practice that saw chains of causation running from God's mind down through spiritual intelligences and the heavenly bodies to animals, plants and stones. By identifying the links between the spiritual, celestial, and terrestrial realms, a knowledgeable philosopher could in principle use these occult powers for practical ends. The *Calendarium* thus offers a compendium of useful knowledge that supplements Agrippa's hierarchical scheme with material from other printed and manuscript sources, including the *Heptameron* (*Magical Elements*) of Pietro d'Abano (Peter of Abano) (*c.* 1257–1316).

The *Calendarium* thus gives insight into one line of enquiry being pursued in the early 17th century. It was, however, a worldview that was falling out of fashion within a few decades and largely considered obsolete by the century's end. Nevertheless, the print retained some interest to antiquarians and collectors. There are, for instance, manuscript copies dating from the mid-17th to the 19th centuries,[†] as well as copies of the print in other collections.[‡] A copy (cut into sections) at the University of Glasgow (MS Ferguson 2), for example, came from the library of John Ferguson (1837–1916), Professor of Chemistry at the university, whose interests included the history of chemistry, alchemy, Rosicrucianism and witchcraft. This is a reminder of one way in which material evidence of the history of alchemy has survived – bound up with chemistry's early history – contrasting the more uneasy attitude astronomers have typically shown towards astrology.

Richard Dunn

† E.g. National Library of Austria, Vienna, MS. Lat. 11313; Wellcome Library, MS.321, MS.2640 and MS.2641.

‡ E.g. Getty Research Institute, 2005.PR.90**.

...	♊ . ♎ . ♒ .	♋ . ♏ . ♓ .	♉ . ♍ . ♑ .
...N.	DIAPHANVM.	AGILITAS.	SODALITAS.
...	SPIRITVS.	ANIMA.	CORPVS.
...LECTVS.	RATIO.	PHANTASIA.	SENSVS.
...	VIVERE.	SCIRE.	INTELLIGERE.
...S.	OCCASVS.	MEDIVM COELI	IMVM COELI.
...NDENS.	DESCENDENS.	PROGREDIENS.	CIRCVLARIS.
...ANTIA.	QVALITAS.	QVANTITAS.	MOTVS.
...TVM.	LINEA.	PLANITIES.	PROFVNDITAS.
... Seminari	NATV: PVLLO.	ADOLENS forarn:	COMPOSITVM.
...	ESSENTIA.	VIRTVTE.	ACTIONE.
...ENTIA.	IVSTITIA.	TEMPERATIA.	FORTITVDO.
...ALOP.	AMADICH.	EMACHIEL.	DAMALECH.

...VATERNARIVS RADIX ET FVNDAM...

ה	CHYROMANTIA SINISTRÆ.	ד
...NERA.		IHESV.
...VA.		AER.
...GETATIVA.		SENSITIVA.
...VS.		AVDITVS.
...TVRNVS.		IVPITER.
...PIDES.		METALLA.
...MINES.		QVATRVPEDIA.

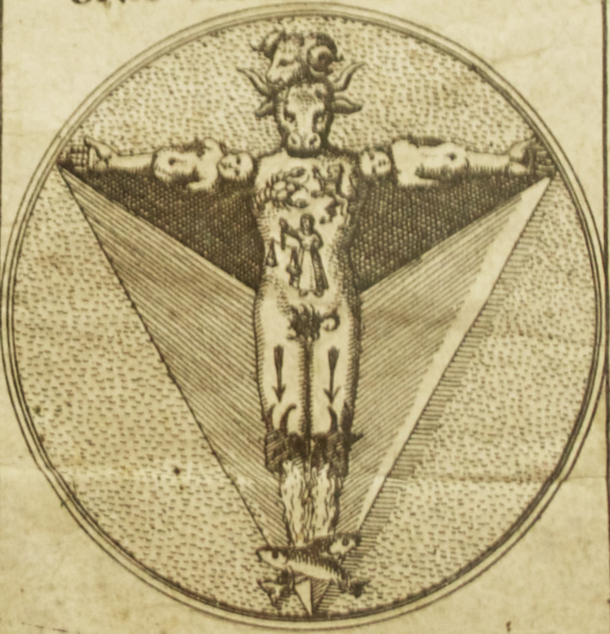
...VINARIVS DENARII MEDIETAS EX...

ד	ו	ב	
...PHIM.	CHERVBIN.	THRONI.	
...VRNVS.	IVPITER.	MARS.	
...TICVS.	ANTARCTICVS.	TROPICVS.	
...NITVDO.	COLOR.	FIGVRA.	
...	RARITAS.	ACVITAS.	

No:	Ve...
1	22
2	23
3	24
4	25
5	26
6	27
7	28
8	29
9	30
10	31
11	1
12	2
13	3
14	4

MENTVM NVMERORVM, FONS NATV

IMAGO HOMINIS 12 SIGNA COMPLECTENS.



CHRISTI
IGNIS.
CONCVPISCIBILIS.
OLFACTVS.
MARS.
PLANTÆ.
REPTILIA.

HOMINIS FIG
NETAS CONT

PARI ET IMPARI TANQVAM MARI ET

IANVAR		FEBRVAR		MARTIVS		APRILIS		MAIVS		[illegible]		IVLLIVS		AVGVST		SEPTEM:		OCTOB	
Ort:	Occas	Ortg	Occas	Ortg.	Occasg	Ortus.	Occasg	Ortg.	Occasg	[illegible]	[illegible]	Ortg.	Occasg	Ortg.	Occasg	Ortg.	Occasg	Ortg.	Occas
752	448	77	453	618	542	521	639	431	729	359	81	43	755	444	716	538	622	632	528
751	49	76	454	616	544	518	641	430	730	359	81	46	754	445	715	540	620	633	527
750	410	74	456	615	545	517	643	429	73[illegible]	359	81	47	753	447	713	542	618	635	525
749	411	72	458	614	547	515	645	427	733	358	82	48	752	449	711	544	616	637	523
748	412	71	459	611	549	514	646	426	734	358	82	49	751	451	79	545	615	638	520
747	413	659	51	69	551	512	648	424	736	359	82	410	750	452	78	547	613	641	519
746	414	657	53	67	553	510	650	423	737	358	82	411	749	454	76	54[illegible]	611	643	517
745	415	655	55	66	554	59	652	422	739	358	82	412	748	455	75	551	69	644	516
744	416	653	57	64	557	58	654	420	740	358	82	413	747	457	73	552	68	646	514
742	418	652	58	62	558	55	655	419	741	357	83	414	746	459	71	554	66	648	51[illegible]
741	419	650	510	60	60	53	657	418	742	357	83	415	745	51	659	556	64	650	51[illegible]
740	420	648	512	558	62	52	659	417	743	357	83	416	744	53	657	558	62	652	58
738	422	646	514	556	64	51	71	416	744	357	83	417	743	55	655	60	60	653	5[illegible]
737	423	644	516	554	66	450	73	415	745	358	82	418	742	56	654	62	558	655	5[illegible]

Calendarium Naturale Magicum Perpetuum, astrological / cosmological calendar, compiled by John Baptist Grosschedel, published by Johann Theodor de Bry, German, *c.* 1619

Wh.6716

The *Calendarium Natural Magicum Perpetuum* is a remarkable summary in words and pictures of the hierarchical, spiritual, and intellectual universe inhabited by some Renaissance scholars. This world was pervaded by spiritual intelligences – angels – who provided the physical means (though themselves incorporeal), by which God maintained, provided for, and controlled his created world. Within it, the place of man was not fixed. Composed of gross corporeal matter, which would eventually decay, man was also endowed with spiritual qualities. By the exercise of his intelligence, purified in spirit, he could have communication with God and exert some control over the intermediate spiritual powers. It was as an aid to such operative, spiritual magic that the *Calendarium* was created. Simultaneously, it provides a map of the celestial and spiritual hierarchies, an *aide-mémoire* to the symmetries and harmonies, conjunctions and oppositions playing in the celestial and terrestrial worlds. It was a useful tool for the philosopher/magician preparing to operate within them.

Universal in intention, the *Calendarium*, nonetheless belongs to a specific historical context. Its immediate source is the de *Occulte philosophiæ* of Henry Cornelius Agrippa although this was not itself an original work, rather a synthesis of earlier occult traditions. It is also closely related to the later Pseudo-Agrippa continuation of this work that provided the practical instructions on how to conjure spirits lacking from Agrippa's own work. The *Calendarium* offers a visual summary of what the magician needed to have in mind while conjuring. Set out in a visual arrangement that allows the correspondences of the different elements to be directly read off, it was clearly a powerful tool.*

* For a complete translation of the *Calendarium*, with useful introductory matter, see Adam McLean, *The Magical Calendar: A Synthesis of Magical Symbolism from the 17th-*

The *Calendarium* was written in 1614. The original manuscript of it is contained in the British Library, London (Harleian MS 3420). It was intended to illustrate Grosschedel's, *Dispositio numerum magica ab unitate sque ad duodenarium Collecta singulari industria, compilata diversa, magno labore, et investigatione sibi suisque* … , the twelve chapters of which correspond exactly with those of the calendar.[†] According to a note on the Harley manuscript, the *Calendarium* was engraved (by Matthieu Merian), without Grosschedel's knowledge or permission, at Frankfurt-am-Main, at the behest of Martin Ludwig von Remchingen and published by Johann Theodore de Bry in 1618/19. Some copies carry a spurious name and date of 'Thicho Brahe inventor 1582'. That Merian did indeed engrave it is confirmed by his name appearing on the copy held in the Bodleian Library, Oxford (Ashmole Rolls 51). This is one of few, if not the only, copy so signed but given its provenance has to be a 17th century example, although there were a number of later re-issues and manuscript copies.

Anthony Turner

Century Renaissance of Medieval Occultism (Grand Rapids: Phanes Press, 1994).

† Carlos Gilly, 'The Rediscovery of the Original of Großchedel's Calendarium Naturale Magicum Perpetuum', in Carlos Gilly and Cis van Heertum (eds), *Magia, Alchimia, Scienza Dal '400 al '700. L'influsso di Ermete Trismegisto / Magic, Alchemy and Science 15th–18th Centuries. The Influence of Hermes Trismegistus*, 2 vols. (Florence: Centro Di/Edifimi Srl., 2002), I, pp. 310–17.

Gunter quadrant, by John Prujean, English, *c.* 1670

Wh.6722

Gossip John Aubrey recorded, *c.* 1690, the opinion of London mathematical instrument-maker Ralph Greatorex that Edmund Gunter:

> was the first that brought Mathematical Instruments to perfection. His *Booke of the Quadrant, Sector, and Crosse-staffe* did open men's understandings and made young men in love with that Studie. Before, the Mathematicall Science were lock'd up in the Greek and Latin tongues; and so lay untouched, kept safe in some Libraries. After Mr. Gunter published his Booke, these Sciences sprang up amain, more and more to that height it is at now.*

The horary quadrant designed by Gunter (1581–1626) enables the user to measure the height of the Sun and, having adjusted for the date on the calendar scale, the projection on the dial gives the time of day, and also the time of sunrise and sunset. It was a very popular design, and remained in the repertoire of the London trade well into the 19th century. In 1619 when Sir Henry Saville wished to fill the chair he had endowed at Oxford, Aubrey reports:

> he first sent for Mr. Gunter from London (being of Oxford University) to have been his Professor of Geometrie: so he came and brought with him his Sector and Quadrant, and fell to resolving of Triangles and doeing a great many fine things. Said the grave Knight, *Doe you call this reading of Geometrie? This is shewing of tricks, man!* and so dismisst him with scorne, and sent for Henry Briggs, from Cambridge.†

At this time, the use of instruments to provide practical solutions to mathematical problems was frowned upon by purist scholars who expected their students to compute from first principles, using the theories that they had

* 'Edmund Gunter' in O. L. Dick, (ed.), *Aubrey's Brief Lives* – I have used the Penguin English Library edition (1972), pp. 275–76; E. Gunter, *The Description and Use of the Sector* (London, 1624); David W. Waters, *The Art of Navigation in England in Elizabethan and Early Stuart Times* (London, Hollis & Carter, 1958), pp. 358–92, stresses the importance of Gunter's contribution to popularising the new mathematical navigation both by written and instrumental methods.
† 'Henry Savile', in Dick, *op. cit.*, p. 431.

been taught. During the 17th century, that attitude began to weaken, and some of the credit must go to men like Gunter, whose 1624 book provided a sound theoretical explanation of the various instrument designs that it contained.

Many Gunter quadrants survive, giving witness to the popularity of this form of sundial. There are 10 other examples of the design in the Whipple Museum's collection. What makes this instrument of particular interest is that it is a made in paper, not brass. It was produced by the London-trained mathematical instrument-maker, John Prujean, who worked in Oxford from 1664 to about 1710. Prujean produced a range of instruments, printed on paper from engraved plates, and many, including the Gunter quadrant, were sold with a printed instruction sheet.[‡] They were inexpensive, and so ideal for purchase by students. That means that however popular they were at the time, ephemeral paper instruments have a very poor survival rate.[§]

David J. Bryden

‡ *A Description of Gunter's Quadrant* (Oxford, for John Prujean, n.d.) – copies in British Library 1850.c.10(70) and Warwickshire Record Office, CR136/D1/11/73; David J. Bryden, 'Made in Oxford: John Prujean's 1701 Catalogue of Mathematical Instruments', *Oxoniensia* 58 (1993), pp. 263–85; David J. Bryden, 'Addenda to John Prujean's 1701 Catalogue of Mathematical Instruments', *Oxoniensia* 83 (2018), pp. 261–65.

§ David J. Bryden, 'The Instrument-Maker and the Printer: Paper Instruments Made in 17th Century London', *Bulletin of the Scientific Instrument Society* 55 (1997), pp. 3–15.

Custom interference microscope, designed by Andrew Huxley, made by R. and J. Beck, English, 1952–53

Wh.6743

Readers might be aware of Liba's great fondness for frogs. Physiologists also esteem their 'little friend the frog,'* albeit not in quite the same way. These 'old martyrs of science' proved popular with physiologists from William Harvey to Luigi Galvani and beyond.† One of the many triumphs of physiologists and their frogs was the development of the sliding filament theory of muscle contraction.

In 1949, Andrew Huxley and Alan Hodgkin were concluding the action potential research that led to their joint 1963 Nobel Prize in Physiology or Medicine. Huxley, seeking a new challenge, decided to switch to muscle research. He was intrigued by an unexplained phenomenon observed by 19th-century microscopists: the formation of 'contraction bands' and a 'reversal of striations' during muscle contraction.‡

Huxley sought to pair the visual changes with the elements of contraction. He chose frog muscle, which he could manipulate so activation, tension development, and shortening were distinguishable.§ However, frog muscle striations were too fine to observe via ordinary light microscopy, and the fibres were too thick to observe their striations via phase contrast. Further, the reversal did not appear in polarised light. Interference microscopy, Huxley realised, could capture the narrow frog striations and their changes. This provided an excuse to indulge his passion for microscopy.¶

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* A. V. Hill, *The Ethical Dilemma of Science and Other Writings* (New York: Rockefeller Institute Press, 1960), p. 31.

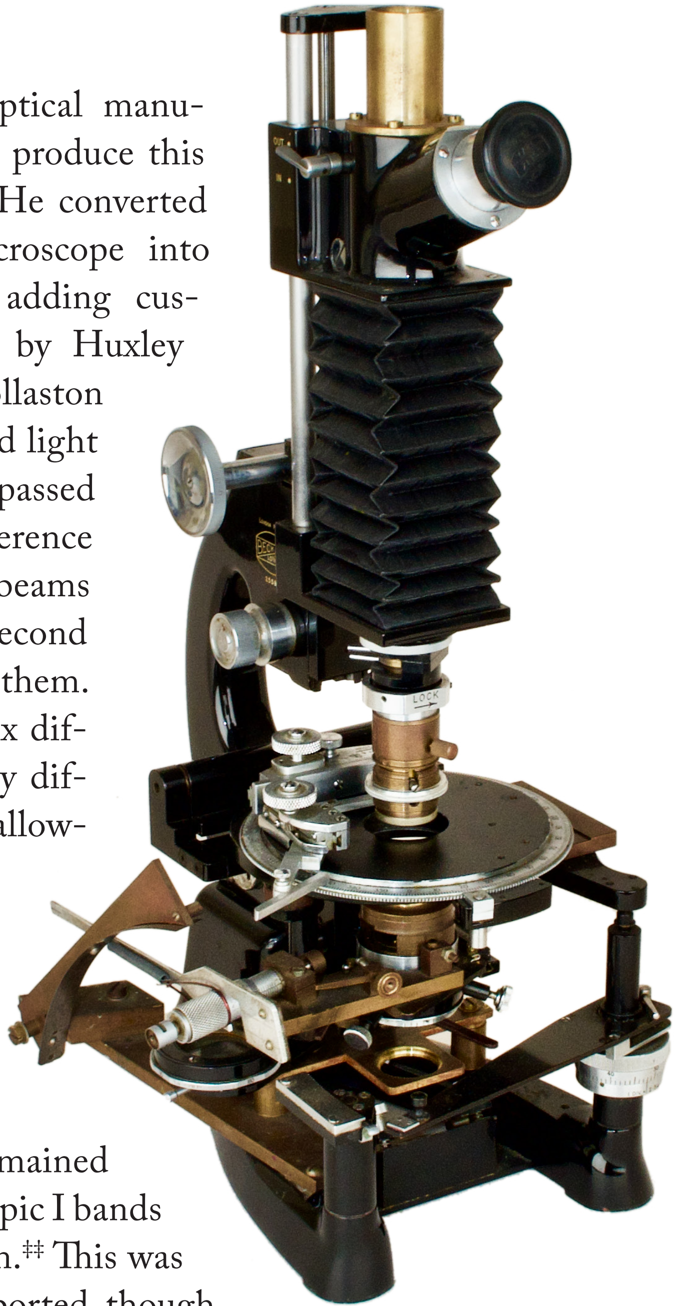
† Frederic L. Holmes, 'The Old Martyr of Science: The Frog in Experimental Physiology', *Journal of the History of Biology* 26 (1993), pp. 312–27.

‡ Andrew Huxley, 'The Florey Lecture, 1982: Discovery: accident or design?', *Proceedings of the Royal Society of London* 216 (1982), 253–65, on p. 255.

§ Andrew Huxley and Rolf Niedergerke, 'Structural Changes in Muscle During Contraction', *Nature*, 173 (1954), pp. 971–73.

¶ Andrew Huxley, 'Andrew F. Huxley', in Larry R. Squire (ed.), *The History of Neuroscience in Autobiography*, vol. 4 (Burlington: Elsevier, 2004), pp. 284–318; Huxley, 'The Florey

Huxley collaborated with the optical manufacturer R. & J. Beck Limited to produce this custom interference microscope. He converted a standard Beck polarising microscope into an interference microscope by adding custom components – some made by Huxley using his childhood lathe.** A Wollaston prism below the condenser divided light into two sections. One beam passed through the sample, and the reference beam bypassed it. After the two beams passed through the objective, a second Wollaston prism recombined them. This converted the refractive index differences in the fibre into intensity differences in the resultant image, allowing Huxley and his partner Rolf Niedergerke to view the striations.††



Experimentation yielded three key observations. First, the birefringent anisotropic A bands remained constant in size, whereas the isotropic I bands changed length during contraction.‡‡ This was the opposite of what textbooks reported, though it supported the theory that A bands are primarily

Lecture, 1982', *op. cit.*
** Huxley, 'Andrew F. Huxley', *op. cit.*, p. 300.
†† Andrew Huxley, 'Applications of an interference microscope', *Journal of Physiology* 117 (1952), pp. 52P–53P; Huxley and Niedergerke, 'Structural Changes in Muscle', *op. cit.*, p. 971.
‡‡ Andrew Huxley, 'Mechanics and models of the myosin motor', *Philosophical Transactions of the Royal Society of London B* 355 (2000), pp. 433–40; Andrew Huxley and Rolf Niedergerke, 'Measurement of the Striations of Isolated Muscle Fibres with the Interference Microscope', *Journal of Physiology* 144 (1958), pp. 403–25.

composed of myosin rods of fixed length. Second, the reversal of striations occurred as the fibre changed length; activation and tension development alone did not alter the striations.[§§]

The third observation was most vital. Huxley had hypothesised that contraction bands appeared when the ends of a rodlet crumpled against its neighbouring rods in the middle of an I band. He was surprised to observe that this phenomenon was preceded by another: narrow, dense CM bands appeared at the centre of each A band. Huxley and Niedergerke concluded that thin actin filaments alternated with and slightly overlapped the myosin. During contraction, the filaments slid into the A bands as they shortened, forming CM bands where their ends collided.[¶¶] They published in 1954 alongside Hugh Huxley (no relation) and Jean Hanson, who independently conceived the same theory.

Huxley treasured this microscope and personally arranged for its donation.

Dannielle Gieryńska

§§ Huxley and Niedergerke, 'Structural Changes in Muscle', *op. cit.*, p. 972.
¶¶ Huxley and Niedergerke, 'Measurement of the Striations', *op. cit.*, pp. 420–21; Huxley, 'The Florey Lecture, 1982', *op. cit.*, p. 258.

Whipple
Museum
of the History of Science