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Essay review

Victorian Telescope Makers, The lives and letters of Thomas and Howard Grubb, by I S Glass (Institute of Physics Publishing, Bristol, 1997), xiii + 279 pp. ISBN 0 7503 0454 5, £25, hardback, 160 ×240 mm.

With his crude telescope, constructed in 1610, Galileo Galilei made many striking discoveries. With his findings and persuasion to investigate the laws of nature, he laid down the elementary concepts of modern experimental science. The invention of a telescope immensely enhanced our vision and awareness of the universe.

Astronomical telescopes have undergone enduring improvements in accuracy and optical sophistication so as to become the most important tool which permits astronomers exploration of the immense space of the tantalizing to us natural world. The aperture of the modern telescope's optic now reaches double digits in metres and optical lenses are replaced by optical mirrors of glass ceramic, with zero expansion coefficient. One pair or several telescopes can be connected by optical fibres to form a single combined image equivalent to an increased telescope aperture. Segmented thin mirror telescopes of 10 metre aperture are now assembled supported by innovative devices - the so-called 'active optic' where the primary, segmented mirror is supported on many points by computer operated alignments to correct for distortions of the mirror shape due to transfer of weight during changes in the pointing of the telescope. The recent introduction of 'adaptive optics' provides a corrected image, nearly free of distortions caused by Earth's atmosphere.

Visual observations with an eyepiece are seldom performed at present. Photographic plates, photocells, photomultipliers, television cameras, deep cooled charged Couple Devices, and computer sampling techniques have replaced the observer and allow speedy, high volume, and more reliable collection of data. Robotic telescopes are interfaced on-line to computers to exploit the immense potential of this technique in otherwise laborious and time-consuming data acquisition. The Hubble Space Telescope has proven its advantage in exploration of both deep-space and solar-system objects. Communications technology facilitates the transmission of commands and data to and from the space telescopes. Numerous space probes and orbiting satellites, operating at wavelengths not obtainable from Earth's surface, now can access the entire electromagnetic spectrum.

All current technological developments were easily and successfully achieved due to the steady improvement in telescopes and auxiliary equipment design.

This volume by Ian S Glass outlines the efforts of the Victorian nineteenth-century enterprise of Thomas and Howard Grubb, father and son, of Dublin, Ireland, to achieve excellence in their telescope making, specifically to equip telescopes with sturdy, durable mounting, providing the stability essential for pointing and tracking accuracy.

The author, who grew up in Dublin close to the Grubbs and their facilities, was astonished that so little had been documented about the work and high standard telescope-making firm of Thomas and Howard Grubb. Having access to extensive collections of the Grubbs' surviving correspondence he succeeds, through numerous quotations from their own letters and business replies, to present their struggles and triumphs and provide a perspective of their private lives.

The book's 279 pages and many illustrations begin with the author's acknowledgements for help received with the preparation of this volume and a forward by Patrick Moore. The lives and contributions of these celebrated telescope makers to produce worldwide so many and some of the largest and most famous telescopes of their time is given in another ten chapters, followed by three Appendices: A– Publications by T Grubb, B – Publications by H Grubb, and C – List of Grubb Telescopes.

Thomas Grubb (1800-1878), by nature an inventive person, abandoned his position as clerk in a Dublin house in favour of his hobby in optics. He was inspired in astronomy through his acquaintance with the Revd Thomas Romney Robinson, Director of Armagh Observatory, however other important people played an important part. In 1832, he constructed a small observatory and established an engineering business, producing machine tools and astronomical instruments, as well as cast iron billiard tables and beds. This unusual blend of activity led later to the typical strong, cast iron construction of the housing accommodating the telescope drive mechanism together with gears and drive sector and formed support for the polar axis. This type of assembly was a marked improvement in stability compared to previous designs. To relieve the friction between the moving parts, in the absence of ball bearings, different devices were applied without compromising the stability of the axial systems. 'The Equilibrated Lever' system of mirror support, the cell holding the primary mirror and minimizing distortion, was first applied by T Grubb. He also contributed to the development of engraving machines, microscopes with angle adjustment of the specimen illumination, and magnetometers to measure the strength of Earth's magnetic field. Thomas Grubb was highly interested in photography and patented camera lenses. Ireland and England experienced an inventive period with tools and manufacturing industry developing rapidly along with economic prosperity.

The production of a good telescope demands maximum precision in optical and mechanical accuracy. Exceptionally exact tools and uncommon machines to achieve this goal must be developed. This applies to grinding, polishing, and figuring of the glass optic as much as to the required mechanical tolerances. Most of the needed equipment was built in the Grubb Optical and Mechanical Works in Rathmines. Suitable optical quality glass discs of large diameter were not readily available to the Grubbs and extraordinary effort was required in manufacturing and testing the vital telescope objectives and mirror optics. Lens and mirror figuring was a laborious task due to bad quality glass and the inability at this time to produce homogeneous glass over large discs. Each time, with every new attempt, a new set of conditions not met before were experienced. Lens making was considered an art, dependent largely on the intuition and experience of the maker to improve on both spherical and chromatic aberration along with image quality.

The Grubbs built more refracting than reflecting telescopes, but were quite aware of the advantages of large mirror telescopes and the limitation in the production of larger optical objectives. The customers' demand was, however, directed more towards refractors at this time and for this reason they endeavoured to supply the astronomical community with these. In astronomical research, the telescope type used depends sometimes upon the specific aim of the investigations and the advantages which this telescope type offers.

After the retirement of his father and notwithstanding a high school and university education, Howard Grubb (1844-1931) had, by nature, rather a practical than theoretical aptitude and used to solve problems experimentally. He expanded the company quickly and was very busy, with the greatest turnaround occurring from 1880 to 1894. He was very inventive and manufactured telescope objective lenses of exceptionally-high quality. He improved considerably the accuracy and free movement of worm-screw and drive sector-arc by grinding the two together. The periodic error caused by eccentricity of the wheels of the clock drive was eliminated and a satisfactory slow motion, free of backlash was provided. Clamps in right ascension and declination, which did not change the setting position of the telescope when applied, were realized. Furthermore, he furnished facility for the focussing and alignment of the photographic plate-holder to be made perpendicular to and centred on the optical axis, as well as a better arrangement for attaching the objective on the opposite end of the tube. All such improvements contributed to better image quality and to a steady drive of the telescope during long exposures. For setting the guiding star in the field of view, a micrometer and cross-wire was employed, instead of a circular hole as used before and utilized microscopes for reading the setting circles from the eyepiece end.

With the advancement of photography and resulting application in astronomy, the Grubbs turned their attention to equip astronomers with telescopes suitable for astrophotography. Following a decision made in 1887 to map the entire sky photographically, the so-called *Carte du Ciel*, a standard photographic telescope of 33 centimetres aperture and 3.43 metre focal length was proposed. Since the early photographic emulsion was most sensitive to blue light, the Astrographic Telescope was built so as to give best performance at 4308 Å wavelength of the electromagnetic spectrum. Later, with the improvement of the photographic emulsion to be sensitive for the entire visual spectrum, the visually-corrected telescopes also became available for celestial photography.

With constant development, the advancement of astronomical telescopes and auxiliary equipment accelerated and diversified. A new type, the so-called Siderostatic telescope or 'polar refractor', was designed by Grubb. This is to some degree the predecessor of the Coudé focus configuration with telescopes used mainly for spectroscopy, but differs from the Coudé (elbow) telescope of Loewy in Paris. Heliostat steerable plain-mirrors mounted on top of observing towers to track the Sun and reflect its image for observation and spectroscopy down in a shaft where a fixed telescope arrangement was located, were built by Grubb. Also for long focus photographs of the Sun during eclipse events, to measure the deflection of light by gravity according to the Einstein theory of relativity, heliostats were employed to reflect the Sun's image in fixed telescopes mounted horizontally on Earth's surface. Heliometers, for accurate measuring of very small angles between celestial objects, were mounted on telescopes to be used during the transit of Venus expedition. Spectrographs, objective prisms, circle division machines, micrometers, numerous telescope domes and entire rising floors were a successful preoccupation of the Grubbs. At the end of his career, H Grubb preferred to build twin refractors and full worm-wheels instead of worm-sectors, to eliminate rewinding and provide for more even wear.

Hopes for even larger telescopes were maintained for the future by H Grubb and the use of reflectors was proposed. A schema for a large reflector with a primary mirror constructed of speculum metal mounted in a telescope tube and enclosed in a spherical segment to be supported by water flotation, was outlined. Proposal for an extremely large, fixed reflector telescopes with an equal diameter steerable flat mirror were discussed but found not realistic.

Consecutively with the famous 27-inch refracting telescope of the Vienna Observatory in Austria, the Transit of Venus expedition telescopes as well as the *Carte du Ciel* Astrographic telescopes, there are short accounts given in the book of many notable telescopes made by the Grubbs. The list of Grubb designed, improved, or entirely newly built telescopes with apertures from 3-inch to 48-inch (the Great Melbourne Telescope with speculum mirrors) and located in different parts of the globe exceeds 120.

Howard Grubb invented for use in the gun turrets of battleships an outstanding device, a type of periscope. Later he improved on its design to be used with submarines. It is claimed that that he supplied 95% of the British submarine periscopes during WWI.

But there were also difficult years in the life of H Grubb with labour troubles and strikes and telescopes remaining unfinished during the war period. The factory was moved from Dublin to the Fleet Works, St. Albans (Hertfordshire, England) to avoid threat by German submarines in the Irish Sea. After the war it became evident that their financial position had become more critical and the established firm of Sir Howard Grubb and Son Ltd., St. Albans, went into voluntary liquidation and was subsequently sold. In 1925, Sir Charles A Parsons, youngest son of Lord Rosse, purchased from the liquidator the Grubb enterprise and a new company trading as Sir Howard Grubb, Parsons and Co. was formed and workshops were erected at Heaton, Newcastle-on-Tyne. There the Pulkovo solar spectrograph and the Simeis reflector for Soviet Russia were completed. Unfortunately, this firm discontinued manufacture of astronomical equipment in 1985.

The Grubbs were prominent in the scientific community in Ireland and England and attained worldwide recognition for their contribution to telescope technology. They both were elected Fellows of the Royal Society, London, with Howard being knighted in 1887.

I have had the opportunity to use the Vienna 27-inch refractor, the largest in the world when commissioned, also the 13-inch Astrographic telescope of the Perth Observatory at Bickley, Western Australia. Both, with slight improvements, are still in continuous use as evidence of their durable construction and superior quality of workmanship.

The book is well presented and makes for pleasant reading and is certainly of historical value for astronomers, telescope makers, students of technology and science, and surely for anyone with curiosity about the achievements of the past century..

Looking to past achievements can help us to meet the future with greater confidence.

Ivan Nikoloff

Review

Astronomy before the Telescope, edited by Christopher Walker (British Museum Press, London), 352 pp. + 20 colour plates, ISBN 0-7141-1746-3, £25.00, hardback, 195 × 250 mm.

Nineteen authors (including the editor) conduct the reader back in time to most areas of the world, which still leave some areas and cultures to be researched, and some excluded from the book for one reason or another. Astronomy and/or astrology do not go back as far in time as some mythological concepts, such as those of the Australian Aborigine, who had not developed the art of written records before the arrival of Europeans on the continent during the seventeenth century and permanent European settlement at the end of the eighteenth century. This same unfolding of information applies to the bulk of the continent of Africa.

The volume is divided into a Foreword by Patrick Moore and seventeen chapters, the last of which deals with the ancient recorded observations and their application in modern astronomy. The other sixteen chapters are devoted to geographic regions, races, periods, cultures, or religions so that some cross referencing is necessary for they are in themselves separate entities. 'Astronomical records' prior to 1609 can be broadly divided into six groups: archaeological, visual observations, instruments, agricultural/calendar, mathematical interpretations of observations, and cosmological/mythological ideas all of these are covered in this volume.

Beside the one hundred plus excellent illustrations and twenty colour plates, there are eleven maps for ten of the chapters which make it so much easier to visulize the locations about which the author is writing. There is a good index which details the various aspects of the book, although I found difficulty with the use of continuous figure numbers when I started looking at the page number instead (if all else fails, read the instruction manual). The extensive bibliographies to be found at the end of each chapter are most useful, and those readers not greatly familiar with the subject will find them very useful.

The first essay describes archaeoastronomy in Europe, which, like the Great Pyramid, suggest an association with astronomical objects, but no practical applications. This is followed by the Egytpian contributions to our knowledge of a 365-day year and a 12-hour day and night. They were amongst the first to use astronomical phenomena for practical purposes – agriculture. Two thousand years of Mesopotamian astronomy are succinctly covered, despite the mathematical nature of its contribution to future generations of Greek philosophers. The latter are covered in two essays on pre- and post-Ptolemaic astronomy, when celestial phenomena were studied in a scientific fashion. The part played by the Romans is considered briefly in their ability to spread existing knowledge.

Four essays are devoted to European astronomy – archaeological, Middle Ages, Renaissance, and pre-telescopic instruments – occupy a quarter of the book and give an erudite summary of our present knowledge of the area's astronomical history and heritage.

The remaining six essays are of geographical or religious disciplines. David King in his essay on Islamic astronomy starts with, "From the ninth century to the fifteenth, Muslin scholars excelled in every branch of scientific knowledge. In particular their contributions to astronomy and mathematics are impressive". Impressive is the word to describe the work carried out by Muslin scholars in the three sides of the Mediterranean Sea. Indian, Far East, American, African, and Australasian astronomical concepts are considered in the remaining six essays. It is a pity that more space could not have been devoted to such a large part of the globe, perhaps some other publisher will take up the task of welding together authorities on their parts of astronomical history.

Astronomy before the Telescope is a book which can be picked up for a short reading session without loosing the thread, and for an abstract of the book, Patrick Moore's Foreward is excellent. At the end of his forward, he gives the rationale behind the book "It was designed to complement the range of the British Museum's own archaeological and historical collections, and to look beyond mathematics and trigonometry to the contemporary cultural milieux and the surviving material remains." This it does.

John Perdrix