THE GRUBB CONTRIBUTION TO TELESCOPE TECHNOLOGY

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ABSTRACT

For almost 100 years the Grubbs of Dublin, Ireland, were famous for the telescopes they supplied to observatories worldwide. Two generations of the family dominated this unusual enterprise. Their success can be attributed to innovative engineering, often introduced at the urging of their most demanding customers.

Thomas Grubb (1800-1898) was encouraged to become a telescope maker by Romney Robinson of Armagh Observatory. Rigid heavy mountings characterized his instruments and made them relatively vibration-free. Early in his career he mounted a Cauchoix lens in what was briefly to be the world's largest refractor (Markree). He went on to supply instruments to the Royal Greenwich Observatory in England and the West Point Military Academy in the United States, among others. His innovative mirror support system was adopted by the Earl of Rosse for his giant reflectors.

Howard Grubb (1844-1931), the younger son of Thomas, was responsible with his father for the Great Melbourne Telescope and later on his own for the 27-inch telescope at the K & K Observatory, Vienna. A talented engineer, he made many improvements to telescope controls, drive motors and mountings. As a skilled optician, he ground and polished many large lenses including some of the first wide-angle photographic objectives.

The history of the firm has been documented by Glass (1997) and Manville (1971).

EARLY DAYS OF THE FIRM

Thomas Grubb grew up as a member of the Quaker community in Waterford, Southeast Ireland. Many of the local Quakers were entrepreneurs operating in the fields of engineering and shipbuilding. Thomas, however, 'married out' and was ejected by his co-religionists. The details of his education are unknown. The firm that he founded first appeared around 1832 as a manufacturer of metal billiard tables but it was soon active in many other areas including instrument making and machine tool construction. Later on it produced photographic lenses and specialised printing machinery for banknotes.

Figure 1. Daguerrotype of Thomas Grubb, probably ca. 1840s (Photo: Mrs V. Coburn).

Thomas Grubb's first large telescope was a reflector with a speculum metal mirror. To prevent flexure as its position changed, he devised one of his most important inventions, his so-called 'Equilibrated levers'. Today this form of mirror support is usually referred to as the 'whiffle-tree system'. Probably equally important was his introduction of solid stone piers and cast-iron axes to ensure freedom from vibration.

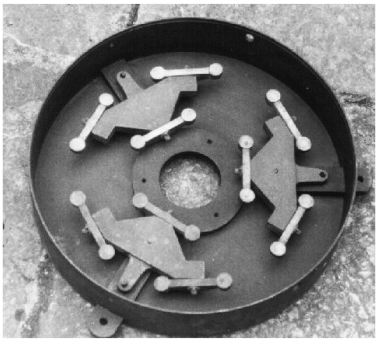


Figure 2. Mirror cell of the Armagh 15-inch reflector. This was the first use of Grubb's 'equilibrated levers' (Photo: author).

In fact, the Armagh mount was an experimental model for the Markree refractor. Edward Joshua Cooper, a wealthy Irish amateur, had bought a 13.3-in Cauchoix objective lens, the largest ever made, in Paris. At first he had placed it on a very poor altazimuth mounting made of wood. Robinson persuaded Cooper to

purchase an equatorial mounting from Grubb and this proved highly successful. The poor climate at Markree however limited the telescope's usefulness.

This and other very early Grubb telescopes show evidence that they were originally built with worm-and-wheel right ascension drives. The wormwheels were soon replaced by toothed sectors of much larger radius. The newer arrangement must have offered greater precision of motion and freedom from vibration.

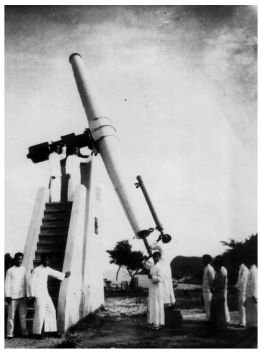


Figure 3. The Markree refractor (1834) in its last incarnation at a Jesuit seminary in Hong Kong in the 1930s (Photo: Late F.J. Heyden, SJ).

Thomas Grubb was aided greatly in finding customers by Thomas Romney Robinson, the Director of Armagh Observatory, whose background was in mathematical physics. He was also acquainted with William Parsons, Lord Rosse, the builder of giant telescopes. Rosse adopted Grubb's mirror mounting system for his own 72-inch reflector, the 'Leviathan of Parsonstown', and later Grubb used Rosse's technique for casting speculum metal mirror blanks. With his 72-inch Rosse discovered spiral nebulae.

G.B. Airy, the Astronomer Royal, visited Grubb in Dublin and commissioned a mounting for a 6.75-inch Cauchoix lens from him in 1837. Airy's approval of the resulting telescope (known as the Sheepshanks Refractor) was an important feather in Grubb's cap.

Figure 4. The governor-controlled drive motor of the Sheepshanks Telescope, similar to those of the Armagh reflector and the West Point refractor (Photo: John Butler, Armagh).

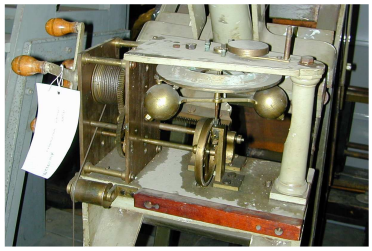


Figure 5. The Sheepshanks Refractor (1839). It is mounted here on a metal frame whereas it would originally have been attached to a masonry pier. It is currently in storage at the Royal Greenwich Observatory. (Photo: John Butler, Armagh).

In 1840 William Bartlett of the West Point Military Academy ordered a mounting from Grubb for a 6-inch telescope by Lerebours, also a Parisian maker.

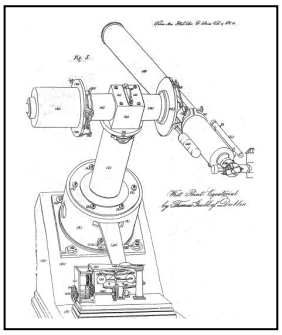


Figure 6. The West Point refractor (1840). The polar axis was enclosed in a cast-iron tube, as adopted later for Howard Grubb's 'Standard Equatorial' (Bartlett, 1846).

Thomas Grubb was the first person to use ray tracing for lens design. However, his only important telescope objective was a 4-element design for Robinson, who incorporated it in a mural circle at Armagh.

Following a period during which he is not known to have constructed any telescopes, Grubb mounted a 12-inch lens by Cauchoix for Dunsink Observatory in Dublin. The result was known as the South Telescope, after Sir James South, who in 1863 donated the lens after losing a law case against Troughton and Simms over an allegedly inferior mount that they had supplied. The Dunsink telescope had a cast iron stand instead of a stone pier as previously employed by Grubb but the polar axis was exposed as in previous telescopes.

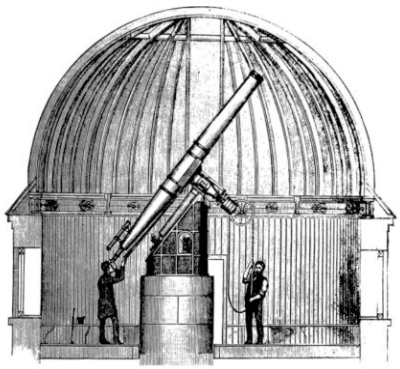


Figure 7. The South Telescope at Dunsink (Ball, 1911).

GREAT MELBOURNE TELESCOPE (GMT)

The project for a large southern telescope was first mooted in the late 1840s. Robinson and Rosse were heavily involved and pushed a proposal from Thomas Grubb who finally in 1866 received a contract for a 48-inch equatorially mounted reflector to be installed in Melbourne, Australia.

Figure 8. Howard Grubb (Photo: Mary Lee Shane Archives, Lick Observatory).

During the construction Howard, then a student at Trinity College in his third year of engineering study, left university and took over the project from his father. Somewhat controversially, it was decided to use speculum metal for the mirror even though Foucault had in 1862 constructed an 80-cm silver-on-glass.

The casting of the first blank seems to have been a significant social occasion (see figure).

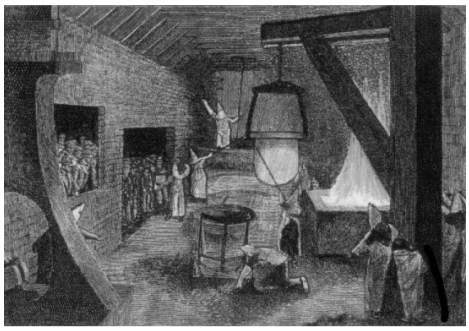
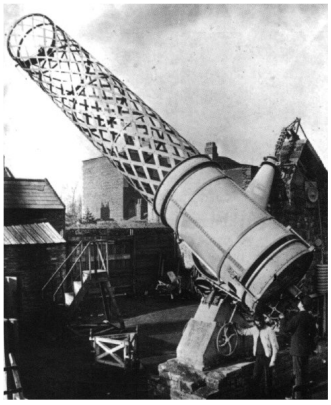


Figure 9. Casting of speculum mirror blank for Great Melbourne Telescope (Fitzgerald, 1896).

The telescope was completed in Dublin by February 1868 and thereafter shipped to Melbourne where observing commenced in August 1869. The maintenance of such a large telescope was not a trivial matter. For example, the speculum mirror was subject to tarnishing and had to be re-polished quite frequently. It was quite possible for an unskilled operator to destroy its figure. In addition, the Cassegrain focal ratio was far too high (F50) to produce images of sufficient brightness. The difficulty of using the telescope and its lack of astronomical productivity are thought to have set back the



construction of reflecting telescopes until the efforts of Ritchey and Hale several decades later.

Figure 10. The completed Melbourne telescope while still in Dublin (Photo: SAAO).

Thomas Grubb had scant success at first with polishing machines. However, that which he designed for the Melbourne telescope was very successful and similar ones are still in use.

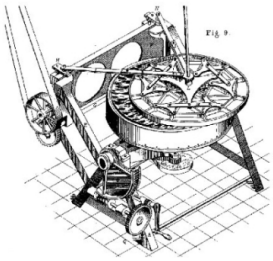
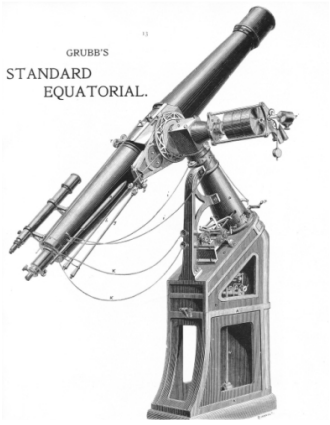


Figure 11. Grubb polishing machine supplied for use with the Great Melbourne Telescope (Robinson and Grubb 1869).

THE OPTICAL AND MECHANICAL WORKS

By 1869 Thomas Grubb had retired and Howard had taken over the firm. Also around this time the physicist G.G. Stokes, then very influential as the Secretary of the Royal Society (London), began to offer advice on difficult optical questions and to generally support the Dublin company. Together with Robinson, he persuaded the Royal Society to sponsor a 15-inch Grubb refractor to be lent semi-permanently to William Huggins, the pioneer of spectral analysis in England. Soon afterwards, Howard built a 24-inch reflector for the Royal Observatory, Edinburgh (1872).

The year 1872 saw his first meeting with David Gill, who was to become one of the leading observational astronomers of his time. Gill had been trained as a watchmaker and was a highly competent instrument designer. He was at the time employed by Lord Lindsay to help with the construction of his private observatory at Dun Echt in Scotland. Gill exerted considerable pressure on Grubb to ensure that the



telescopes he was providing to Lord Lindsay incorporated all the latest improvements in design.

Figure 12. Howard Grubb's Standard equatorial. By this time the fine motions and clamping arrangements had been greatly improved. This design was used many times for medium-sized telescopes (Grubb 1890).

In 1875 Howard Grubb secured a contract for a 27-inch telescope to be installed in the Royal and Imperial (K und K) Observatory in Vienna, together with several domes. This led him to construct a factory called the 'Optical and Mechanical Works' on land his father had purchased in the suburb of Rathmines, where the GMT had been constructed some years before.

Figure 13. The Optical and Mechanical Works, Rathmines, Dublin, 1875 (Photo: Universitätssternwarte, Vienna).

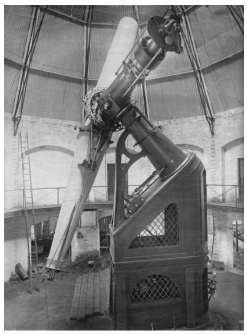


Figure 14. The 27-inch refractor that Grubb built for the K & K Observatory in Vienna. This was the largest in the World for a short time. It is seen here in the assembly hall of the Rathmines works in about 1881. The procurement of large enough pieces of optical glass for this and some later telescopes was extremely difficult. (Photo: Universitätssternwarte, Vienna).

PHOTOGRAPHIC TELESCOPES

In the mid 1880s David Gill at the Cape of Good Hope realized that the dry plates then available were sensitive enough to be usable for making sky surveys. With financial support from James Nasmyth, a pioneer of the machine-tool industry and a wealthy amateur, he ordered a telescope from Grubb that was designed to be achromatic in the blue region to which alone the plates were sensitive. However, the objective was a failure because it lacked a wide enough field, having been designed as if it were for a visual refractor, where on-axis performance was all that mattered. Gill's first survey, the Cape Photographic Durchmusterung (CPD), was therefore made with a Dallmeyer portrait lens that offered reasonable definition over a large field.

The success of the CPD led to the Paris Astrographic Congress of 1887 under the leadership of Admiral Mouchez and Gill. Meanwhile, the Henry brothers of Paris had been successful in designing photographic objectives with a large field. The Congress decided to press ahead with a collaborative photographic survey of the sky, the so-called 'Carte du Ciel', using telescopes of 33cm aperture and 3.43m focal length. Each participating observatory would have charge of a certain declination zone. The Astrographic project required about 12 telescopes and Grubb supplied half of these. Achieving a design as good as the Henry brothers' one cost Grubb a great deal of anxiety and almost led him to a nervous breakdown. Apart from the optical problems he encountered, it was necessary to develop very precise drives to allow for very long exposures.

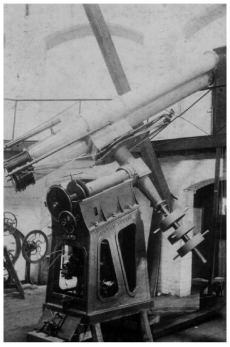
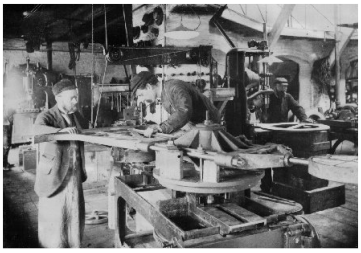


Figure 15. Grubb's first 'Astrographic' telescope at his works before delivery to Mexico. A photographic telescope and a guider were mounted together (Photo: SAAO).

He devised new machines for precision gear cutting and also invented a system for controlling the telescope position from a precise clock. This



may have been the first example of a 'phase-locked loop'. The conditions for stability were arrived at empirically.

Figure 16. Cutting the teeth of a drive sector in Grubb's works (Photo: SAAO).

DESIGNS OF THE 1890s

The 1890s were characterized by a number of unusual designs.

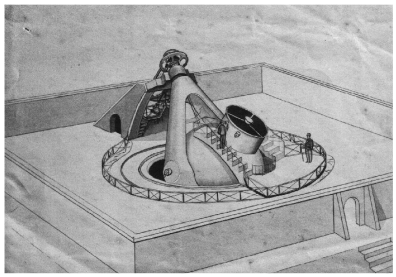


Figure 17. Grubb's Proposal for a 100-inch giant telescope using flotation to relieve stress on the bearings (Photo: SAAO).

For example, because Gill thought he could persuade one of the South African diamond millionaires to finance a large telescope, Grubb prepared a design for a 100-inch reflector, the load on whose bearings he proposed to relieve by enclosing the mount in a sphere floating in a water bath.

Several heliostats were constructed for eclipse expeditions. One of these, owned by the Royal Irish Academy, was used later in the 1919 Sobral verification of the predictions of general relativity concerning the deflection of starlight by the Sun during an eclipse.

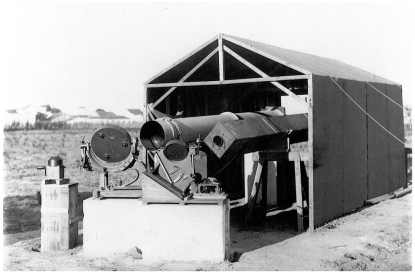


Figure 18. Grubb siderostat and 4-inch telescope (right) at Sobral during the famous eclipse expedition that verified General Relativity (Photo: Ian Elliott, Dunsink).

The Sheepshanks coudé for Cambridge was an unusual design that allowed the observer to work in

indoor comfort. This telescope was used by Russell for determining some of the parallaxes for his version of the Hertzsprung-Russell diagram.

The first Grubb mount to use a full wormwheel instead of his usual sector was that supplied to Max Wolf of Heidelberg for his Bruce lens. This meant that the telescope no longer had to be stopped for a sector rewind every hour or two. Furthermore, the discontinuous nature of sector drives tended to cause uneven wear of the gear teeth.

The same decade saw a number of large refractors including his largest, the 28-inch visual instrument for the Royal Greenwich Observatory (1894). Others were the Thompson dual 28-in reflector/ 26-in photographic refractor for the same observatory (1897) and the McClean photographic refractor for the Cape of 1900.

Reflectors did not figure greatly among Grubb's projects, but he did re-figure the 36-inch mirror of the Crossley telescope of Lick Observatory in 1896.

POST-1900

After 1900 Grubb became heavily involved in the manufacture of periscopes for the submarines that were then coming into use in the Royal and other navies. Following an unfavourable comparison of his designs with those of continental manufacturers around 1910, he employed Cyril Young as a design engineer. Young had previously worked for T. Cooke & Sons and had been Works Manager for the Cambridge Instrument Co.

Though naval contracts soon came to dominate the business, a number of significant telescope projects were also taken on. These included a 24-inch for Santiago, Chile and a 26½-inch for Johannesburg, South Africa. The designs of these telescopes were radically modern compared to Grubb's previous ones. For example, ball bearings were used for the first time. A large contract was placed in 1912 by the Imperial Russian government for the observatory at Simeis in the

Crimea, including a 32-inch refractor, a 1-m reflector, a solar spectrograph and the necessary domes. All these projects were delayed by WW1 since the firm had to concentrate on war production.

LAST YEARS OF THE FIRM

Because of fears that German submarines in the Irish Sea would lead to loss of the valuable war materiel being supplied by Grubb, the Navy insisted that the firm should move to England. The move to St Albans took so long that the War was over before it was complete.

The economic conditions following the War were such that the Grubb firm could no longer continue trading in the old way. The firm gradually slid into bankruptcy and was only sustained by carefully monitored progress payments from the South African and Soviet Russian governments. Nevertheless, their important contracts were completed.

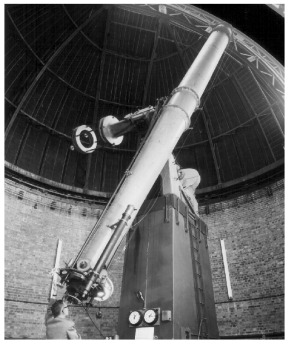


Figure 19. The 26½-inch Johannesburg telescope which was the last large refractor produced by the firm. The influence of Grubb's new engineer, Cyril Young, is seen in the sturdy mounting of the polar axis (Photo: SAAO).

The firm went into liquidation in January 1925 and was almost immediately bought out by Sir Charles Parsons, the youngest son of the telescope-making Earl of Rosse and a celebrated entrepreneur who had made a fortune through the development of steam turbines. Under the name of Grubb Parsons, it carried on until 1985.

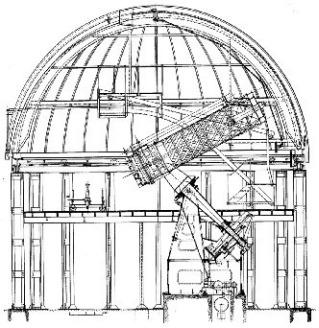


Figure 20. The Simeis 1m reflector, Howard Grubb's largest telescope. It was destroyed during WWII (Anon, 1926).

It is sad to relate that the two of the biggest Grubb telescopes were ultimately destroyed. The (much modified) Great Melbourne Telescope, which had seen the most useful phase of its existence in the MACHO gravitational lensing experiment, was lost in the Mount Stromlo fire of 2003 and the Simeis 1m reflector was dismantled and scrapped by the Germans during the Second World War.

Howard Grubb left the firm on its being taken over by Parsons. However, his son Romney R. Grubb stayed with them for a few more years before being eased out. Thus ended the family involvement.

REFERENCES

Anon., 1926. *Catalogue,* Sir Howard Grubb, Parsons & Company, Publication No. 4.

Ball, Sir Robert, 1892. *Story of the Heavens*, London: Cassell & Co.

Bartlett, W.H.C., 1946. *Trans. Am. Phil. Soc*., **9**, pp.191-203 and 5 plates.

Fitzgerald, W.G., 1896. *Strand Magazine,* **12**, pp. 369-381.

Glass, I.S., 1997. *Victorian Telescope Makers, the Lives and Letters of Thomas and Howard Grubb*, Bristol: Institute of Physics Publishing.

Grubb, H., 1890. *Catalogue,* Dublin.

Manville, G.E., 1971. Two *Fathers and Two Sons,* Newcastle upon Tyne: Reyrolle Parsons Group (pamphlet).

Robinson, T.R., Grubb, T., 1869, *Phil. Trans. R. Soc.,* 159, pp. 127-161.